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A TECHNICAL GUIDE. REPORT C--EDUCATIONAL FACILITIES WITH NEW MEDIA.

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THE REPORT PROVIDES DETAILED TECHNICAL GUIDANCE IN MAKING DESIGN DECISIONS. IT IS DIRECTED TO PERSONNEL CONCERNED WITH THE DETAILS OF DESIGN SUCH AS ARCHITECTS, ENGINEERS, SUPPLIERS, AND MEDIA SPECIALISTS. THE DATA OFFER GUIDANCE IN THE PROGRAMING AND PLANNING OF EDUCATIONAL FACILITIES AND INFORMATION ON (1) ENVIRONMENTAL FACTORS AND FURNISHINGS, (2) PROJECTION SYSTEMS, AND (3) MEDIA HARDWARE. THIS IS THE THIRD REPORT IN A SERIES OF THREE, ED 003 131, AND ED 003 132. (RS)

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EDUCATIONAL FACILITIES WITH NEW MEDIA

REPORT C

A TECHNICAL GUIDE

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EDUCATIONAL FACILITIES WITH NEW MEDIA
REPORT C: A Technical Guide

The final report of an architectural research study conducted by the staff of the Center for Architectural Research, School of Architecture, Rensselaer Polytechnic Institute, Troy, New York, under the terms of contract number OE-316-031 between Rensselaer and the United States Office of Education.

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December 1965

INTRODUCTION

A report of architectural research

This report is one of a series of three resulting from a two year architectural research study funded by Title VII–Part B (Dissemination) of the National Defense Education Act administered by the U. S. Office of Education.

Three reports

This series of reports is directed at one objective--optimizing the conditions for learning by providing the environments most conducive to learning when learning media are employed in the educational process. Toward meeting this objective, a body of material–data, design studies, premises, reactions, and conclusions–has been collected and organized to offer guidance in the programming and planning of the appropriate educational facilities. Since a number of different types of persons are involved in providing the educational environment, this guidance is offered in the three reports, each directed to somewhat different, but overlapping, audiences.

Three different audiences

The series has been given the overall title Educational Facilities with New Media. Within this series, Report A–"A Guide for Policy Makers" is directed primarily to boards, administrators, planning committees, and institutional planners; Report B–"A Guide for the Design Professions" is directed to architects, planners and design specialists, as well as planning committees; and Report C–"A Technical Guide" is intended for those concerned with details of design-architects, engineers, equipment and furniture suppliers, and media specialists.

In preparing three reports instead of one, some duplication and overlap among them is unavoidable. However, the content and the manner of presentation of each report have been chosen with these audiences in mind.

INTRODUCTION

Points of explanation

To introduce these reports, several points of explanation should prevent the reader from moving into the reports with false notions as to content and purpose:

Provide proper environments for learning

1. The primary concern is with creating the environments for learning—with planning space and designing educational facilities. More might be said about staff organization, curriculum, teachers, resources, and finances, but this is essentially an architectural research report, and these areas are considered only as they affect school planning.

Not evaluating educational philosophies

2. In dealing with school planning, educational philosophies which serve as the basis for planning cannot be avoided. However, evaluations and judgments as to the relative merits of such philosophies have been avoided as being outside the province of the study. Rather than "here is the way to educate and therefore provide these facilities", the approach has been "if you adopt this philosophy, these are the implications for facilities".

Specifically examing media and facilities

3. Learning media are only part of the current educational scene, and a look at facilities with learning media is not a comprehensive look at all educational facilities. However, there are occassions when examining one aspect of the total system in depth is valid. Emphasis is intentionally on learning media, and their implications for facilities.

Within this framework, it is hoped that the contents of these reports will help guide those persons responsible for providing today's school buildings toward sound educational and architectural decisions.

Contents of this report

As a technical guide the information in this Report C is divided into five parts. Part 1 serves as an introduction to several general concerns—planning for obsolescence, change, expansion, and compatability of equipment. Parts 2 and 3 deal respectively with environmental factors of lighting, acoustics and climate and with furnishing the environment. Part 4 covers the complex problem of designing projection systems which necessitates the proper relationship among projector, screen, controls, projection material, viewing area, and lighting conditions. Part 5 discusses some of the other hardware of media which must be considered in the proper planning and design of educational facilities with new media.

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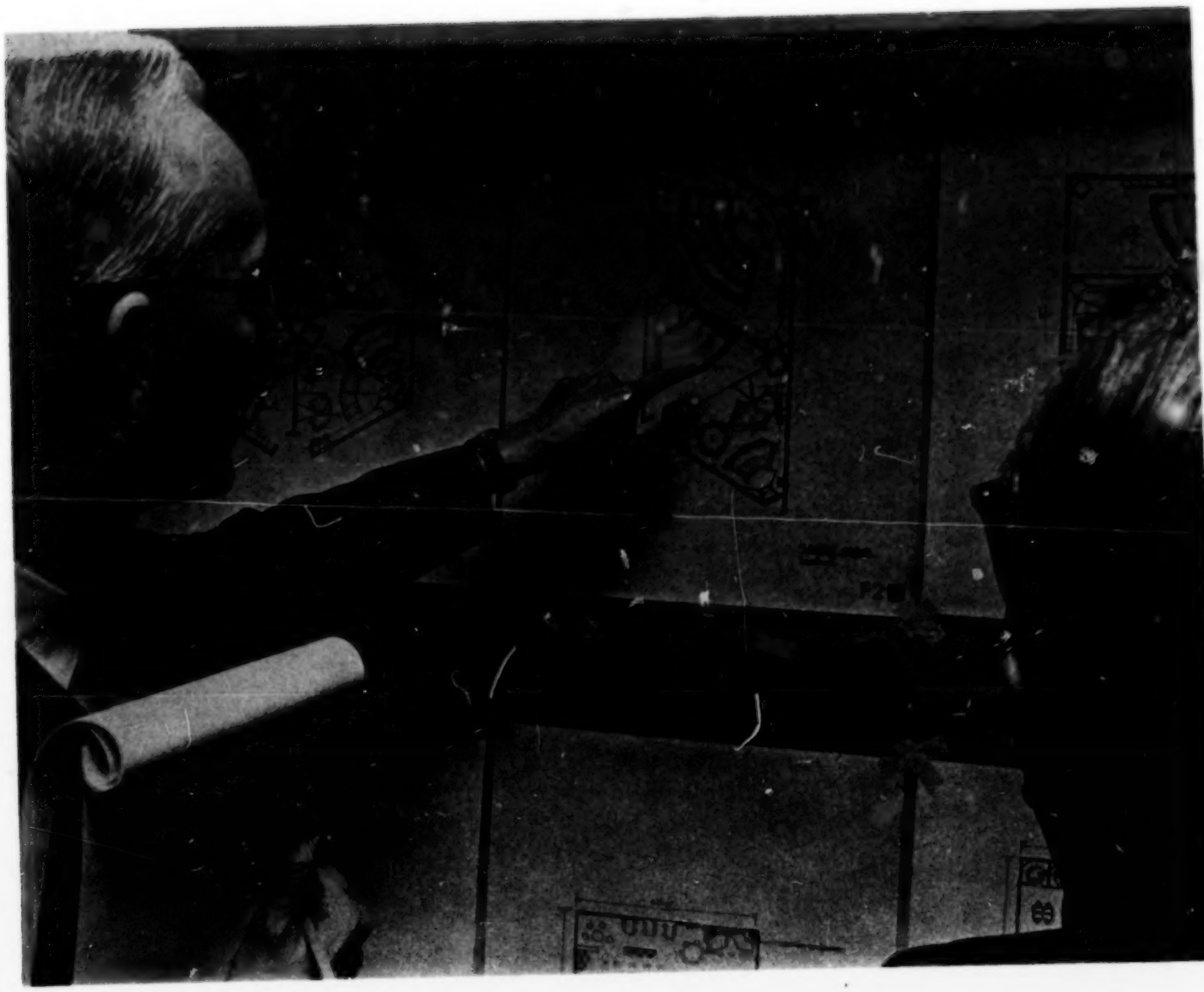


1 TECHNICAL CONCERNS: AN INTRODUCTION

Learning spaces more complex

One fact is evident; educational facilities planned for the optimum use of media do not look like, and are not designed like, the conventional classrooms of the past. Classrooms were once simple enclosures of space containing students, teacher, chalkboards, desks, and some storage cabinets. Changing educational methods, coupled with the uses of media, have changed not only the form of the classroom, but the way it functions.

Technical guidance

Some technical guidance for design of these new learning spaces is necessary; several general principles should be reviewed.

Change and obsolescence

1. Change is the password in the media field, and obsolescence is the constant fear. Equipment and hardware are undergoing constant modifications and improvements; new kinds of equipment and new models of existing types are coming on the market daily. On the one hand educational administrators are understandably reluctant to invest in projectors, TV equipment and other hardware today that may be obsolete tomorrow, yet the teaching staff recognizes that the educational process and facilities for it cannot perform properly until adequately equipped. Several points may help resolve this dilemma:

Buy only what's needed

- Purchase only the equipment needed immediately and which the faculty is able to use effectively. When the remaining equipment is needed, improved models, possibly at lower prices, will be available.

Buy simple equipment

- Purchase initial equipment that will meet basic functional criteria, but which is simple and uncomplicated in operation and generally less costly than the sophisticated, complex equipment that may be more appropriate for later purchase.

Buy compatible equipment

- Whatever equipment is purchased now should form systems of compatible components, and should permit additional components of equipment to be added later.

Budget for change

- Budgets can reflect a realistic approach to equipment change and obsolescence by providing annual funds specifically for replacement, upgrading and expansion of media systems and components. Institutions should not be put in a position where all equipment for a long time to come has to be provided when the building is first built; some of the funds would better be spent in subsequent years for change.

Planning for later use of media

2. Not only does hardware change, but there is another dimension to to the problem. Many spaces designed and built today will eventually contain media hardware even though uses of media in the spaces are not a design factor for the present. How to plan today's schools to also accommodate tomorrow's hardware is the concern. Some points that may help are:

Design basic space correctly now

- Design the spaces properly now so that equipment can be changed and added later. For instance, if in initial design the proper relationship is established between screens and students, the manner in which images are projected can change without changing the room. The introduction of new projection equipment will not necessitate remodelling the room.

Prior planning can simplify change

- Some prior planning will greatly simplify the later installation of more complex and more extensive systems of equipment. For instance, dropped ceilings, open conduit, and large raceways will accommodate future cables and wiring; access panels and frequent juncture boxes will ease the pulling of cabling; extra initial power service in anticipation of added equipment will eliminate problems of insufficient power; lighting which is installed initially to provide multiple levels will allow the later installation of projection equipment with varying image brightnesses; designing for good acoustical isolation now will prevent problems when media employing recorded sound are introduced later; and installing ductwork and equipment areas now for later air conditioning when added uses of media demand it, will reduce the amount of later construction and remodelling.

Not all equipment built-in

- Much of the hardware subject to change does not need to be built into the fabric of the space, but rather may be left free-standing to facilitate modifications and substitutions.

Use of self-contained cabinets

- Often media can later be introduced into facilities through self-contained cabinets which contain projectors, screens, auxiliary display surfaces, and controls. The "media module"

(see Report B) was developed, in part, to help answer the problem of later incorporating media. However, proper viewing area, lighting, power, and circulation should be provided initially.

Budget for remodelling

- Even with the best of prior planning, later incorporation of media may require some remodelling and construction work. As with equipment, some annual budgeting provisions should be provided to cover these changes in facilities. Minor remodelling to up-date facilities and to allow for expanded and improved uses of media is not necessarily a confession of poor initial planning.

Not everything is subject to obsolescence

3. Some parts of learning spaces are far less vulnerable to change and obsolescence than media equipment. For instance, seating should be selected for durability and ease of maintenance, as well as for functional and aesthetic reasons. Good seating is a sound investment and it should be purchased to last. This is true of storage cabinets and casework and other furniture. Good lighting, allowing several levels, should be provided initially as should proper acoustical treatment and climatic conditioning. Those areas of technology not subject to change should be well provided.

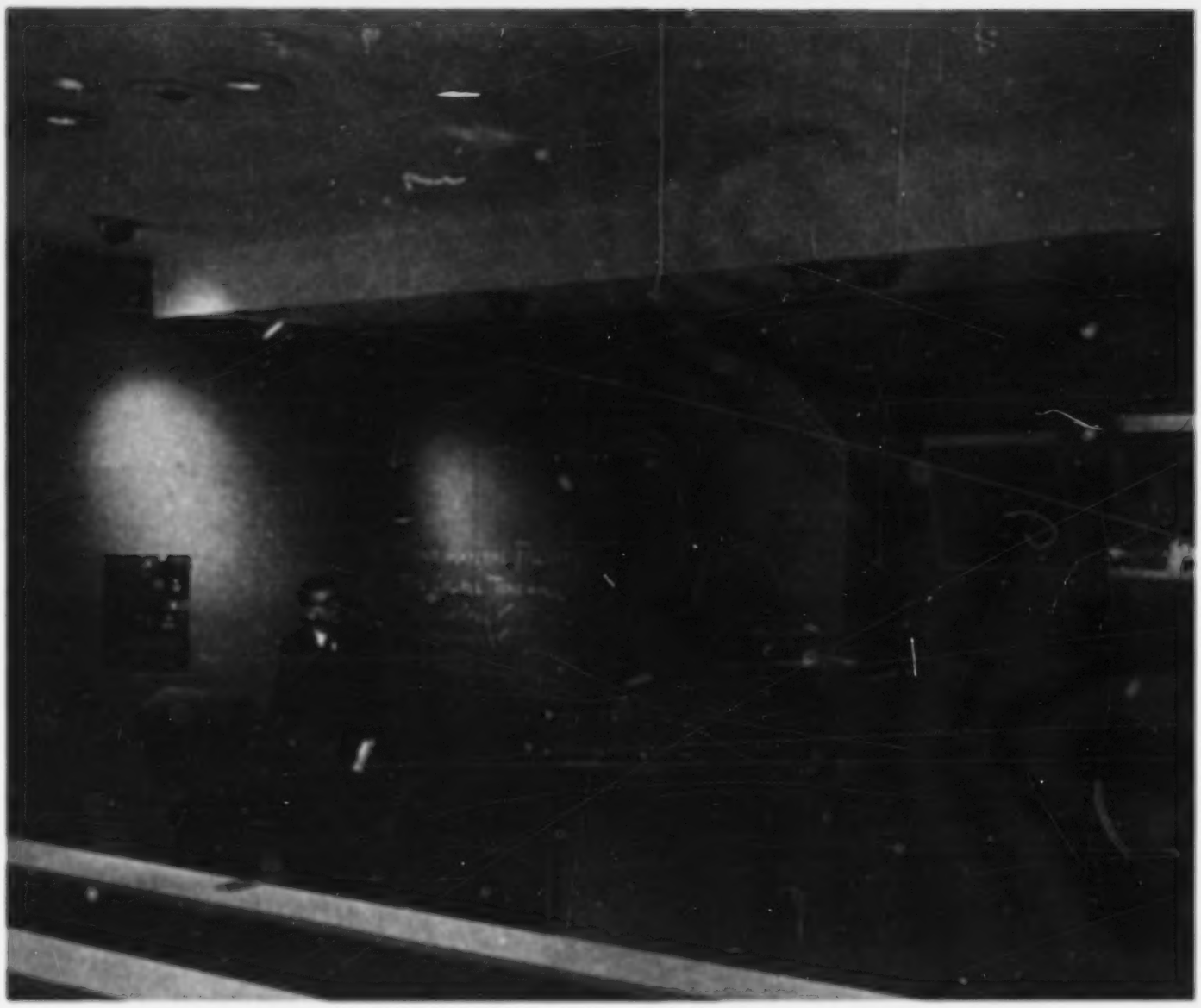
Simplicity the key for teacher usage

4. All apparatus and equipment, all technology, should be designed for simple operation and control. Teachers are generally not technicians and excessive gadgetry and complicated controls will impede the effective uses of media. If one switch will turn on a projector and dim the lights, that is far better than a switch for the projector fan, a switch for the projection lamp, and several rheostats for lighting. This same reasoning applies to all types of classroom lighting, acoustics, climate, and instructional equipment. It also is important when planning and equipping projection areas and studios to be used by teachers. Simplicity is particularly important when teachers and staff have had little previous experience with media. Complexities will turn them away from media, rather than encouraging its use.

Importance of standardization and compatability

5. Standardization and compatability are important in selecting equipment and hardware, in order to simplify maintenance, reduce upkeep costs, and keep down the number of required spare parts. If all 2x2 projectors are the same, rather than many different manufacturers through a district or institution, the savings in time, money and frustration are easy to understand. This is particularly true in selecting television systems and other production equipment. With the growing shortage of technical help qualified to maintain media equipment, standardization and compatability become more and more significant in selecting equipment.

The translation of these general principles on planning the technical aspects are covered more fully in the following discussions.



2 ENVIRONMENT FOR MEDIA: LIGHTING, ACOUSTICS, CLIMATE

Environment must meet physiological needs

Certain physiological needs, including seeing, hearing, and bodily comfort, must be met in order for students to learn within man-made environments. The fact that learning media are part of the educational system places some special demands on the environments in which students, media, and instructor gather for learning. The following guidance is offered to help insure that lighting, acoustics, and climate in learning spaces are planned to encourage optimum learning with media.

LIGHTING

Lighting design begins early

The goal for all school lighting is to allow students and instructors to see comfortably and efficiently, and without undue distraction. Although proper school lighting has been a concern for years, still it often happens that too little attention is paid to the requirements of proper lighting during early planning stages. Too frequently the lighting layout is postponed until all other design problems are solved, instead of considering illumination as a basic ingredient of design. When the question of lighting is belatedly considered, it is frequently found that some of the proper locations for lighting fixtures have been pre-empted by a structural member or a ventilating duct, and the quality of illumination must be compromised.

Lighting and image viewing

The provision of proper lighting is of special importance in learning spaces intended for the optimum use of media; it is the type and quality of lighting during the viewing of images that is important. There is a wealth of available information about proper lighting for conventional learning tasks, but much less is known about proper lighting for image viewing.

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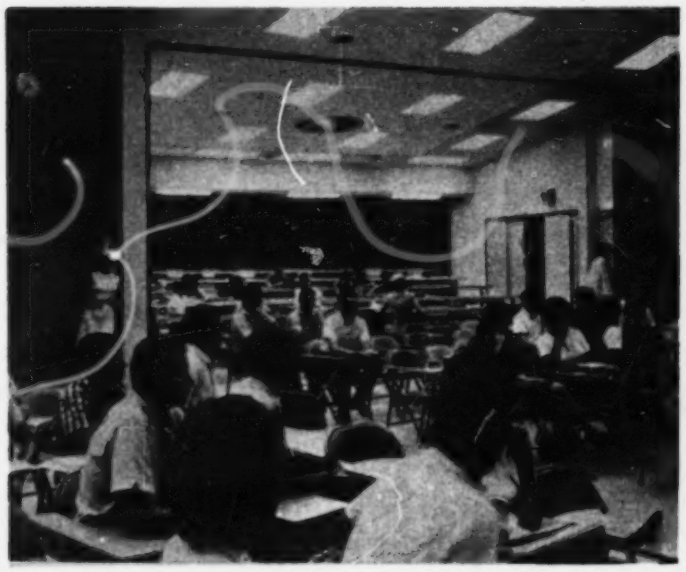
Problems of natural light

In typical classroom situations, illumination is provided by a combination of natural and artificial sources, and often daylight is a major contributor. For ideal projection conditions, though, daylight is often a disturbing factor to be controlled or eliminated. Many of the smaller spaces in which images are projected will have windows, and where they provide too much ambient light on the screen, they will have to be shaded. In the larger spaces intended for the use of projected media, there should preferably be no windows. Artificial lighting can readily be controlled, and in proper amounts is essential to proper viewing conditions. Therefore, the following will deal primarily with illumination provided by artificial means.

Lighting as a tool of design

In the design of interior spaces particularly, artificial lighting should be considered as one of the essential "tools" of architectural design; it may contribute as much as the choice of materials, finishes, or even the room shape itself.



Four functions of lighting

The four basic functions of lighting are to provide:

Visibility, as influenced by the amount, distribution, color and control provided;

Comfort, as determined by the absence of glare and eye strain;

Atmosphere, as provided by the psychological reactions produced; and

Composition, as seen in its effects upon the architectural surroundings.

Proper lighting of the learning spaces should be designed to fulfill all of these functions.

Optimum conditions for viewing media

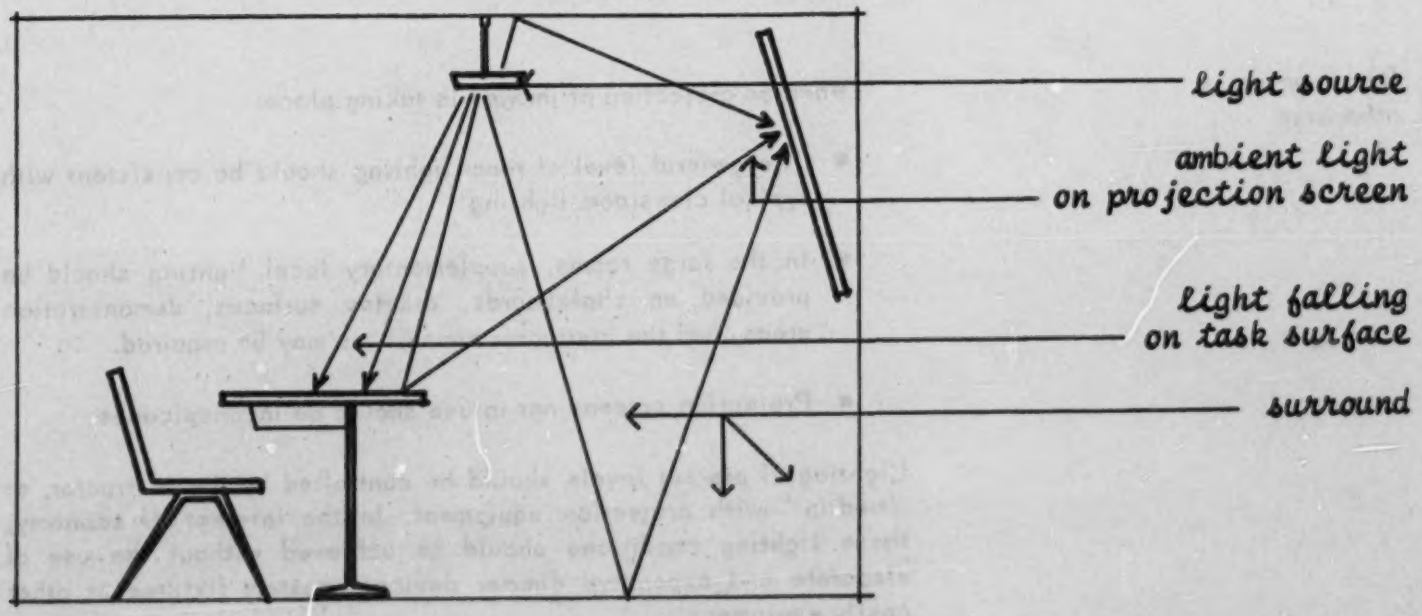
Optimum conditions for the viewing of projected media impose two basic requirements in respect to room lighting:

- the provision of appropriate levels and quality of illumination concurrently on the screen, the task surfaces and the surroundings, and
- the proper means and timing of lighting controls.

The typical conventional classroom is deficient on both counts. Usually darkening of the room necessitates lowering the window shades, or placing special blinds, then turning off the lights, and the light switch seldom is located convenient to the projector. Then there is insufficient light for notetaking, and if the presentation is lengthy, drowsiness overtakes many of the viewers.

Understanding of terms important

In any discussion of lighting the understanding of, and distinction between, certain fundamental technical terms is necessary. Actually we don't see illumination. We see only brightness or light; brightness as reflected from a surface or transmitted through some medium, such as a flame or the sun itself. The light radiating from a source is measured in footcandles; the brightness of a surface, whether due to the reflection or transmission of light, is measured in footlamberts. A lumen is a unit measure of light quantity (luminous energy), and is used in measuring both footcandles and footlamberts. Either one is equal to one lumen per square foot of surface. The essential distinction is that in one case it's light coming from a light source onto the surface (incident light), and in the other, it's light emanating from it, either by reflection or transmission.



2 / ENVIRONMENT

Brightness ratio and contrast ratio

In the main, it is the brightness of surfaces, and especially the relative brightnesses (brightness ratio) of various surfaces within the field of vision, that are of primary concern. It's important to realize that, contrary to a common concept, brightness does not vary with distance. "Brightness ratio" is a term applied to two relatively large areas; "contrast", a term with a similar meaning, refers to the relative brightness of small adjacent areas, such as printed characters and their background.

Requirements of lighting when projecting

The essential requirements of good lighting for optimum viewing of projected images are chiefly these:

During the projection of images on a screen:

- The student's tablet (or writing) surface should be adequately lighted to facilitate taking notes; it should have as nearly as possible the same brightness as the average brightness of the projected image.
- The light falling on this tablet surface should not produce shadows, and the seated student should not be aware of room light sources within his normal line of vision.
- The brightness of other visual task surfaces, such as chalkboards and displays, when in use, should also be about the same as that of the projected image. When not in use, their surface brightness should be lower, to blend inconspicuously with the general background.
- Other surfaces within the viewer's vision, including chalkboards and display areas not in use, should be less bright, but their brightness should not be less than 1/10 that of the average screen brightness.

Requirements otherwise

When no projection of images is taking place:

- The general level of room lighting should be consistent with typical classroom lighting.
- In the large rooms, supplementary local lighting should be provided on chalkboards, display surfaces, demonstration areas, and the instructor himself, as may be required.
- Projection screens not in use should be inconspicuous.

Lighting of pre-set levels should be controlled by the instructor, or "tied-in" with projection equipment. In the interest of economy, these lighting conditions should be achieved without the use of elaborate and expensive dimmer devices, custom fixtures or other costly equipment.

Various media need various lighting levels

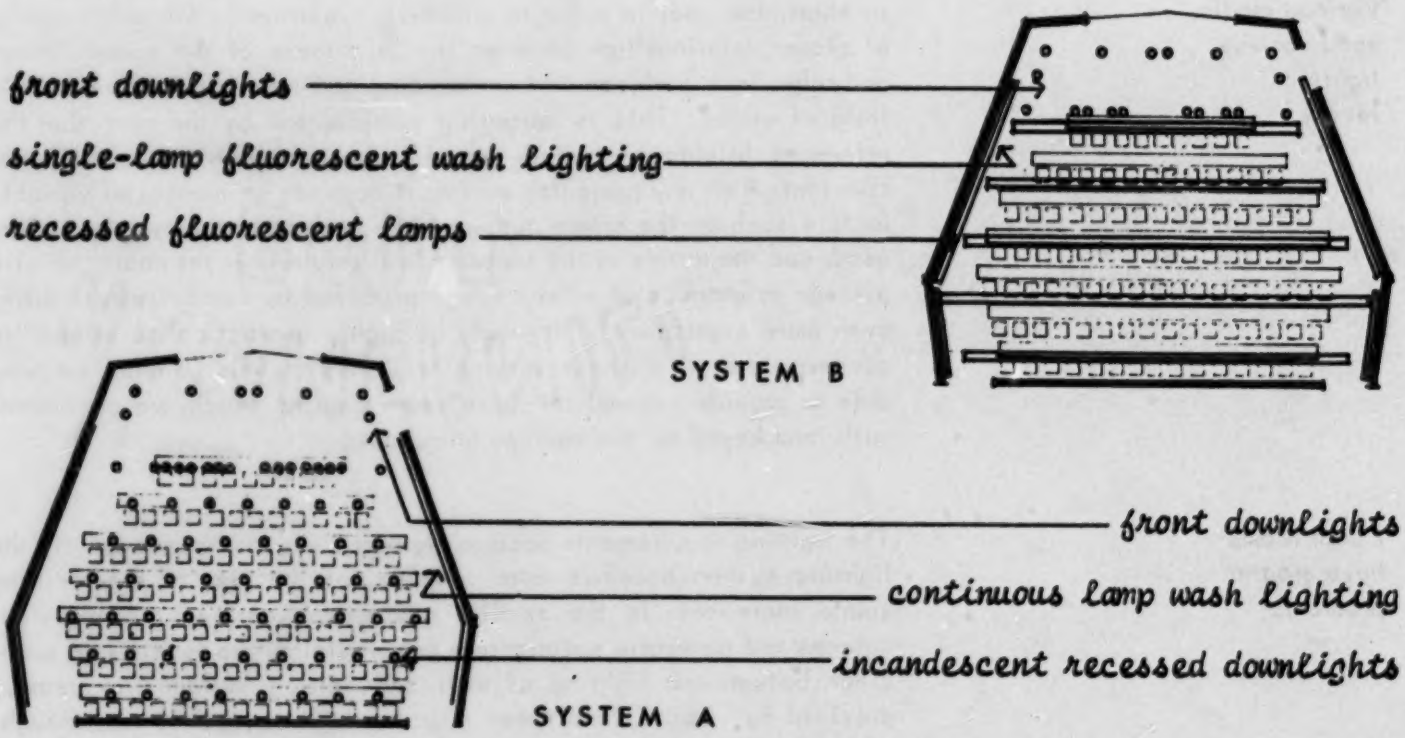
In short, the goal in order to minimize eyestrain is the acheivement of proper relationships between the brightness of the screen image and other task surfaces and surrounding surfaces within the viewer's field of vision. This is somewhat complicated by the fact that the reference brightness value—the average screen brightness—is not constant. With any projected media, it depends on number of variable factors such as the lumen output of the projector, the type of screen used, and the nature of the projected material. Also, the characteristic average brightness of screen image produced by various media differ even more significantly. It would be highly impractical to attempt to accommodate all of these varying brightness levels. But it is advisable to provide several levels of room lighting which are consistent with, and keyed to, the medium being used.

Large rooms have greater problems

The lighting requirements become more critical, and consequently the lighting system becomes more complex, as the size of the learning space increases. In the smaller rooms, conventional ceiling light sources are generally satisfactory for providing two levels and sufficient background lighting of wall and ceiling surfaces is usually provided by "spill" from these sources. In the larger rooms, though, it is usually advisable to provide supplementary special "wash" lighting on the wall areas to bring their brightness up to the proper level in respect to the screen brightness.

Avoid ambient light

It is vitally important in all cases that the room lighting be so directed that as little as possible reaches the projection screen itself. Ambient light on the screen tends to "wash out" the projected image, and its effect becomes more critical as the average screen brightness decreases. Thus, it is particularly important in the larger rooms that projection screens be shielded from stray room lighting.



Two types of systems for large group

For larger spaces two basic types of systems are possible. System A uses incandescent recessed downlights located in the ceiling over the seating area, with auxiliary lighting of the side walls by means of a continuous band of lamps mounted on the wall behind an opaque fascia strip. The whole system is controlled at predetermined levels by means of dimmers. System B consists of recessed fluorescent troffers placed in continuous rows across the ceiling paralleling the seating rows, with a directional 45° cut-off, parabolic reflector grid located below the luminaires and flush with the ceiling. Another line of single-lamp troffers with similar reflector grids is placed in the ceiling along each side wall to provide wash lighting on the walls. This system does not require dimmer controls; instead, several lighting levels can be provided by circuitry and switching. In both systems, accent lighting of the display surfaces, chalkboards, demonstration area and instructor's station can be provided by units recessed in the ceiling. Both systems could be completely controlled from the instructor's station by automatic switching tied-in with the projector controls.

Choice of a system

Naturally there are modifications and combinations of these two systems that would perform satisfactorily. The choice must be made by weighing factors such as initial and operating costs, maintenance costs, reliability, operating noise, and quality of desired light.

Importance of color and texture

In providing appropriate surface brightnesses, the choice of colors and textures is a most important consideration. The writing surfaces (desk or counter tops) should be neither glossy white, producing glare, nor a dark color, contrasting with the writing paper, but should have a light-colored matte finish with a light reflection value of 50 to 60%. The floor, ceiling and walls may be generally light colored, but near the projection screens, they may be darker to minimize the amount of light they reflect on the screens. Chalkboards should have low reflectance to provide good contrast for chalk. The use of bright metal trim anywhere in the room is distracting and objectionable, and should by all means be avoided.

Lighting controls

Appropriate lighting levels should be predetermined and preset, and the instructor's control should extend only to the selection of sequence and duration. It is recommended that when a lectern is used, as in the larger spaces, the lighting circuits be so arranged that they are controlled by the same switches which operate the projectors, so that the switch activating the projector also automatically reduces the level of room lighting, and the switch turning it off automatically raises the room lighting to its normal level. In the smaller rooms lighting will be controlled by simple wall switches, or may be part of the controls built into media modules.

ACOUSTICS

Acoustics a concern in all buildings

Architectural acoustics has long been a matter of concern in concert halls and large auditoria, but only recently has good acoustics in nearly all types of buildings become a concern. With the rising noise level of our modern environment, there is increasing concern with noise control problems, and now acoustical requirements are even being introduced into building codes.

Education depends on communication

Good acoustics are, of course, important in school buildings. Education depends on communication; good hearing conditions are just as essential as good lighting, and both must be carefully considered early in the planning stage. The growing interest in school building acoustics has, in fact, led to many special studies and investigations. Two developments in particular have prompted this concern: the introduction of open planning and the increasing use of electronic media in teaching. Both of these developments are highly significant, and both complicate the "noise problem". Unfortunately, as they affect acoustics, they are basically incompatible.

2 / ENVIRONMENT

Special problems when using media

The fundamentals of acoustics for school buildings are fairly common knowledge; however, it is important to call attention to the essential acoustical features of spaces intended specifically for new media, and to indicate how the basic theory of acoustics affects their design. The use of electronic media is an underlying concern, but the merits of spatial flexibility are also recognized. The implications of both are of special interest.

Two objectives of acoustics

Architectural acoustics should recognize two objectives:

- the provision of good hearing conditions wherever desired, and
- the elimination, as far as possible, of unwanted sound or noise

Both are important in school design, but not necessarily of equal importance in all spaces. This depends upon the intended function of the space.

Hearing Conditions

Factors affecting hearing

Hearing conditions within a room or space depend upon the size and shape of the room, the location and volume of sound, and the disposition of sound-absorbing and sound-reflecting surfaces within the the room. The sound heard at any point within confined space consists of direct sound from the sound source, plus an infinite sequence of sound reflections from surrounding surfaces. The sound level of these reflections–the reverberant sound–depends upon whether the surroundings–the walls, floor, ceiling and furnishings–absorb or reflect the sound. Good hearing conditions are achieved by the control of sound reflection and absorption, and this, in turn, involves several basic requirements:

- the reinforcement, as necessary, of the sound source by reflective surfaces
- the avoidance of long-delayed reflections from remote hard surfaces
- the elimination of inter-reflections (flutter) between parallel hard surfaces
- the control of the persistance of sound (reverberation)
- the control of background noise within the room

Problems vary with size of rooms

Good hearing conditions are obviously essential in all spaces where the learning process requires listening. Listening is essential in learning rooms of all sizes, from the small conference rooms to large auditoria, but good hearing conditions are seldom a problem to achieve in smaller spaces. As the size of the space increases, so also does the importance of acoustical design, and the proper planning of large spaces may require the assistance of acoustical experts.

Small and medium size rooms

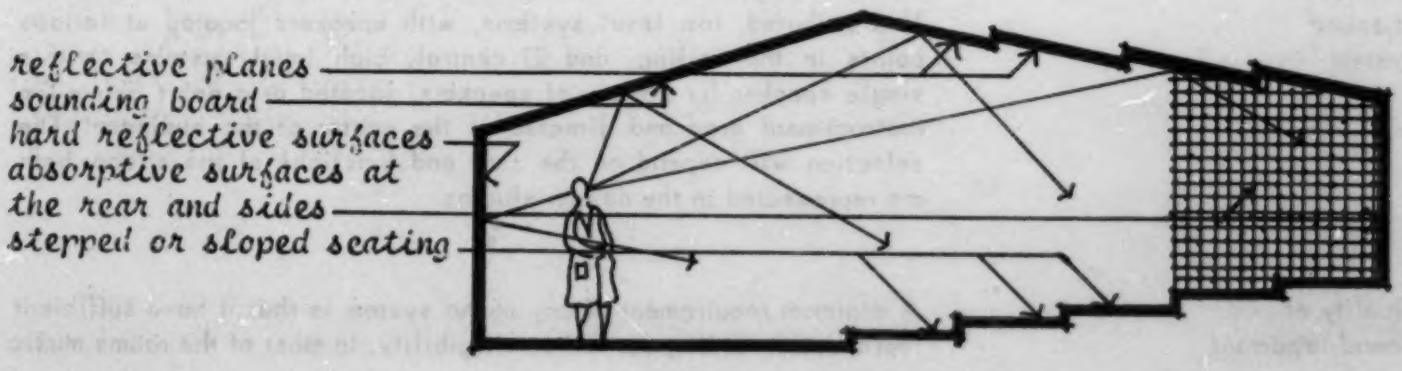
Surface treatments and finishes in small rooms have relatively little effect on hearing conditions. In the medium group spaces accommodating up to 60 persons, it will generally suffice to provide a peripheral area of absorptive material on all sides of the room except that occupied by the instructor. A major part of the ceiling area should be hard and reflective to reinforce the instructor's voice or other sound source.

Large rooms cause biggest problems

In the larger group spaces, the disposition of reflective and absorptive surfaces, including the shape of the room itself, becomes increasingly important as the room dimensions and the distances sound must travel become larger. The objective should always be to so dispose these materials within the room that occupants do not receive perceptibly delayed repetitions of sound. If the surfaces lining the room are hard, and therefore sound-reflective, sound waves are bounced back and forth many times before they die out, and a long "reverberation period" results. When large areas of porous, and therefore sound-absorbent material such as carpet, upholstered furniture or special acoustical "blankets" are introduced, the reflective energy is greatly reduced. Sound is largely absorbed and dies away quickly; the reverberation period is greatly reduced.

Acoustical facts of life

These acoustical "facts of life" have important design implications. They dictate that surfaces relatively close to the sound source should be reflective to amplify and disperse the sound, while surfaces behind the audience, facing the sound source, should be absorptive to minimize reflection and reverberation. The provision, in



effect, of an inclined "sounding board" surface over the instructor's area is essential, and may often be provided by the conformation of the ceiling itself. As a rule, other ceiling surfaces, too, should be reflective, flat planes. Curved surfaces, particularly domes, should be avoided, because they focus, rather than disperse sound. Non-parallel side walls, converging in the direction of the sound source, are preferred, because they improve the dispersion of sound and tend to reduce the reverberation period.

Good sight lines, good hearing lines

As the room size increases, the conformation of the floor area becomes important for acoustical reasons as well as for viewing. Sloped or stepped floors in the larger spaces improve the general hearing conditions, because sound from the front of the room is better dispersed to all members of the audience. It's important to remember that good sight lines mean good "hearing lines".

Sound Systems

Generally amplification of voice unnecessary

Under normal conditions, amplification systems should not be necessary in most of the facilities illustrated in Report B, if the recommendations as to room shape and acoustical treatment are followed. Exceptions will occur in the large rooms where it may be advisable to provide means of reinforcing live speech because of the likely limitations of some speakers. In all of the learning spaces, though, electronically reproduced sounds will be used and facilities should be provided for their distribution. With a built-in sound system being required anyway, it may be desirable in the larger rooms to design it to be used also for amplification and distribution of live sounds. In all cases, there should be only one sound system in any learning space, and it should be capable of accommodating interchangeably all needs—sound tracks on films, audio tapes, radio, television audio, intercom announcements, and, when desired, sounds picked up by room microphones.

Two types of sound system

For the larger rooms, two types of sound systems are available: 1) distributed, low level systems, with speakers located at various points in the ceiling, and 2) central, high level systems, with a single speaker (or battery of speakers) located at a point above the instructional area and directed at the center of the audience. The selection will depend on the size and functions of the space; both are represented in the design studies.

Quality of sound important

A minimum requirement of any sound system is that it have sufficient reproduction quality for full intelligibility. In most of the rooms music

will frequently be reproduced, and in certain rooms this may be the chief function of the system. The tonal quality of the system then becomes of prime importance. It's essential in all cases, too, that uniform volume be provided throughout the listening area with no feedback. When used to amplify live speech, it's important that the amplified sound seems to be coming from the same source as the direct live sound.

Analyze long term costs when selecting equipment

Reliability and low maintenance cost of the equipment deserve more consideration they often receive. If a useful life of from 15 to 20 years without major overhaul is expected, then overall costs, including probable servicing, repairs and replacements should be the governing consideration in selecting the system components, rather than initial costs only. The cheaper installations often prove to be the most expensive purchases in the long run.

Sound Isolation

Amplified sound versus open planning

For reasons previously indicated, the problems of sound isolation between spaces are probably more urgent—and more difficult—in today's schools than are those related to the direction of sound originating within the listening area itself. The expanding use of reproduced sounds calls for improved sound barriers, while at the same time the search for spatial freedom and flexibility encourages the elimination of substantial space dividers. Unfortunately, the invisible sound barrier is yet to be invented and some logical compromise solution is necessary.

Three factors determine quietness

Three principal factors determine the "quietness" of an enclosed space in respect to air-borne sounds:

- the level of sound (noise) in adjacent spaces
- the sound insulation quality of the intervening space enclosure, and
- the level of background noise within the space itself.

It is the relationship of these factors that determines the degree of acoustical comfort experienced in a room. For many years the importance of the sound insulating value (or transmission loss) of walls and floors has been recognized; it's only recently that the significance of background noise has received much attention.

Mass and stiffness of partitions

Sound isolation from outside sources can be provided either by distance or by enclosure. Within a building sound isolation must be provided by floors and partitions, and it's in the construction of partitions that most problems of isolating air-borne sounds arise. The sound–isolating properties of a barrier are determined largely by the mass and inertia of the barrier material. Mass is important, but mass alone is not a dependable measure. Stiffness, or rather the lack of it, may be even more important. A partition consisting of gypsum board on both sides of wood studs which are saw-split to reduce their stiffness, is a better sound barrier than a plastered 6" cinder block wall which weighs almost three times as much.

Partitions must not leak sound

To be totally effective, any sound barrier must be air-tight. Even the smallest openings, such as open joints or cracks, electrical outlet boxes back to back, or keyholes, will greatly reduce the sound–isolating value of a partition. All openings are sound leaks, and have even more significance, relatively, than leaks in waterproofing. A hole of only one square inch in 100 square feet of wall having a 40–decibel transmission less rating will "leak" as much sound as all the rest of the wall.

Improved flexible partitions

It is because of a combination of deficiencies,–light mass, stiffness and most importantly, numerous leaks,–that until recently most reasonable priced flexible or folding partitions have been relatively ineffective as sound barriers. In the past several years, however, this situation has improved. Some manufacturers have developed new products which are better designed and engineered, with careful attention to a better choice of materials and thorough edge sealing, resulting in greatly improved acoustical performance.

Distractions of recorded sound in open planning

In some of the newer schools, open planning has been used extensively with no full partitions separating classrooms or corridors. Proponents of such planning claim that the liberal use of carpeting, acoustical surfacing and baffles, can overcome noise problems. Studies have been made to evaluate this approach to school planning, emphasizing its psychological advantages and attempting to rationalize its acoustical disadvantages. Significantly, although the majority of teachers interviewed appear to find the spaces generally quite acceptable, many of them stated that the use of television, or record playing in adjoining areas is distracting.

Conclusions

General experience, reinforced by such studies as these, has led to several important conclusions:

- The omission of full and substantial partitions between learning spaces limits the proper and effective use of electronic media. Open planning of this type (without full partitions) may be acceptable for some teaching–learning situations, particularly among young children, where a high level of background noise can be tolerated. It cannot be recommended where electronic media are to be regularly used, unless headsets or low volume speakers are employed.

- The minimum acceptable sound barrier between spaces planned for the regular use of electronic media, as in this study, should have a transmission loss of not less than 40 decibels.

Reduce other noises

Background noise level within the learning space itself must also be reduced below objectionable levels. The more commonly disturbing sources are mechanical ventilation equipment and projection equipment.

Enclose projection equipment

It is recommended that an enclosure be provided for all projectors to minimize their noise. In smaller rooms, such enclosures may be simply boxes or "media modules" containing the equipment. Interior surfaces of these enclosures should be lined with sound-absorbent material.

Front and rear projection areas

In the larger rooms, front projection equipment should be housed in permanent "soundproof" projection booths. Projection should be through a glazed panel, rather than open ports, and the glazing should be heavy plate glass set in resilient gasketing. Rear projection spaces for the large rooms must also be carefully designed to confine equipment noise. The projection screen will be vulnerable to sound leakage. If a rigid screen is used, it should be set in resilient mountings. The typical flexible screen has inadequate value as a sound barrier, and should be backed up with a plate glass panel sealed with

a resilient compound or gasket. Both types of projection areas should contain sound-absorbent material, and any doors connecting it with the learning space should be of solid construction and gasketed.

These guidelines for designing acoustically satisfactory facilities with media are only useful if followed early in the design process. Good acoustics cannot be achieved as an afterthought.

CLIMATE

Importance of proper climate

The optimum learning environment is more than simply a physically comfortable climate; it is a climate which encourages learning,—an atmosphere in which the student is alert and attentive. The need for such an atmosphere is particularly essential in spaces where media are being extensively used. In these spaces, the provision of a climate conducive to alert attention is as essential as proper lighting and acoustics; temperature, humidity and air movement should all be carefully controlled.

Providing for air-conditioning

Air conditioning in schools, though a relatively recent innovation, is rapidly becoming common practice in new construction. With more and more schools in all parts of the country anticipating the eventual adoption of a year-round program, it seems that few schools should be built without at least making provision for air conditioning. This will facilitate providing the ideal environment in learning spaces with media throughout the school. Of the schools in use today, however, relatively few are air conditioned. Many of these non-airconditioned schools will be altered and renovated to provide large group learning spaces.

To meet the environmental requirements of these spaces it will be advisable, if not mandatory, to install special air conditioning equipment to serve them.

Special characteristics of large spaces

In general, the climate conditioning of facilities with media poses no unique technical problems, although the need for conditioning and the complexity of the problem increases with the size of the room. In designing the mechanical equipment for the larger group spaces, special attention should be given to the implications of these characteristic conditions:

1. The number of occupants will be relatively large.
2. Many of the rooms will have no windows.

3. Lighting levels, and therefore the heat output from lighting, will vary.

4. Good hearing conditions are mandatory, necessitating careful control of equipment noises.

Even in typical classrooms, cooling...

It is generally known that even in typical school classrooms, more cooling than heating is usually required when outside temperatures are above 25°F, and that good school climate control requires less attention to heating than to cooling in all seasons of the year, regardless of geographic location. Because of the relatively dense population, the high level of artificial illumination, and the often generous use of window glass in typical classrooms, the most common complaints have to do with overheating and poor ventilation. Each occupant contributes about 300 Btu's of heat per hour, and heat is given off by lighting and electrical apparatus at the rate of about 3.4 Btu's per watt per hour. In rooms without windows, where there is much less heat loss through the walls, the need for cooling rather than heating is of course even more prevalent.

...rather than heating, is the problem

Without question, then, the dominant temperature control problem in the larger learning spaces will be that of cooling, when the room is in use. When not in use—off periods, over night and weekends—some heating will likely be required during the normal heating season. In many of these rooms varying levels of lighting, from 5 to 60+ Ft.C. will be used during teaching periods; the maintenance of a proper room temperature under the fluctuating heat output from lighting will be required. In the smaller rooms, portable projectors and other equipment will often be used and they will be significant sources of heat. Projection equipment for the larger rooms will be isolated in separate spaces which have their own ventilation.

Relative humidity also a factor

Humidity, too, must be controlled within an appropriate range, but relative humidity has less significance in providing the proper climate than do temperature and ventilation. Whereas at one time a minimum relative humidity of 50% was generally recommended, engineers now consider a range of from 30% to 55% quite acceptable. To prevent exceeding this top value, it is frequently necessary to provide dehumidification, to remove the moisture given off by the occupants through evaporation.

Importance of proper ventilation

Ventilation will always be required just as it is in most conventional classrooms. Research has established that the chief function of ventilation air is not to replace oxygen or control the carbon dioxide content, as is often assumed, but to dilute body odors which become intensified in densely occupied spaces. Usually, when there are complaints about poor ventilating, it is the "stale odor" that's found

objectionable. Odors may be controlled by several means, but in school buildings they are usually dispelled by dilution with fresh air. This "fresh" air need not necessarily all be outdoor air, however. Recirculated room air that has been cleansed of odors will serve the purpose; its use usually reduces the cost of the ventilating system.

Amounts of ventilation

The amount of ventilation needed to maintain proper oxygen content and limit the carbon dioxide content to a healthy minimum is only about 4 cubic feet per minute per person, but the amount required to dilute odors is much larger, varying with the number of cubic feet of room volume provided per occupant. For sedentary adults, a minimum of 25 cubic feet of fresh air should be provided per person in small, crowded spaces (100 cubic feet of volume per person); in larger, uncrowded spaces (400 to 500 cubic feet of volume per person) this may be as little as 7 cubic feet per occupant. For moderate activity, these amounts should be increased by 50%. Thus the minimum amount of fresh air to be supplied in the larger and medium-sized learning spaces will probably range from 10 to 15 cfm per person, depending on the age of the students. Cooling requirements, however, as opposed to ventilation requirements, will often necessitate introducing larger volumes of air.

Cost of heating fresh air

It should be noted that introducing an oversupply of outdoor ventilating air during the heating season, when this air has to be heated even for cooling purposes, may add significantly to fuel costs and should therefore be avoided. In one study made of two similar schools in Ohio, one of which provided about three times as much outdoor ventilation air as the other, the difference in fuel costs attributable to this factor was over 60%.

Planning air movement

Air movement is a basic essential to the proper learning environment. Sufficient air circulation should be provided over the surface of the body to carry away the layer of warm, moist air covering the skin, but it must be provided in such a way as to avoid noticeable drafts. In the larger rooms, at least, it will probably be advisable to introduce air at or near the ceiling and exhaust it at a low level. Return air grilles should be so located that the air flow is reasonably uniform over the seating area, and will probably be placed either in the side walls near the floor or, in rooms with stepped floors, may be in the riser faces under the seats. If sufficient in number and size, there will be no objectionable drafts.

Mixing systems required

Ventilation will be needed at all times, but temperatures must be held constant. A controlled combination of cooling and heating is required which must be quickly responsive to varying thermal loads within the rooms. There are several types of ductwork and fan systems which can be used to meet these fluctuating requirements. The

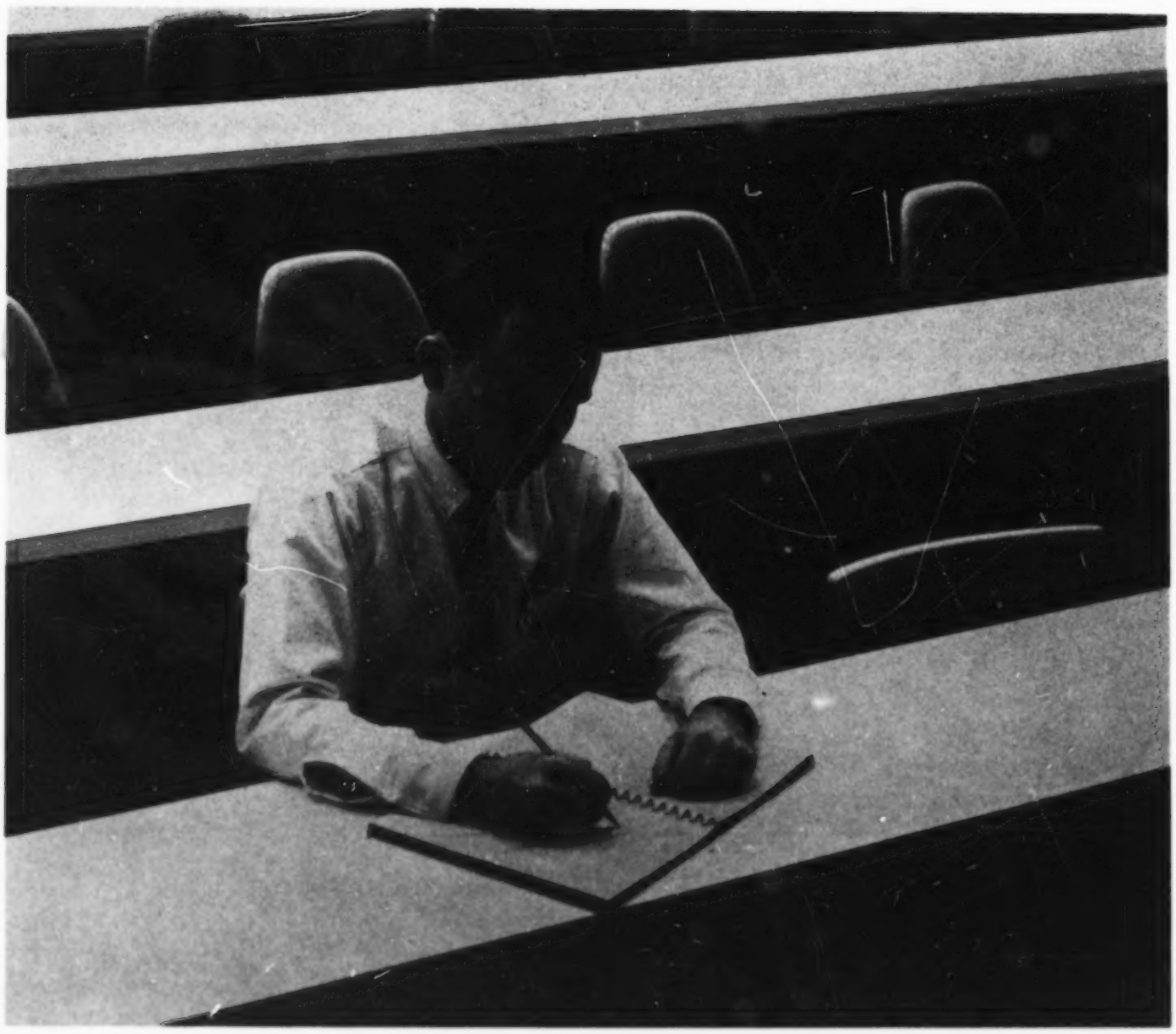
most flexible would be a double duct system, in which air is carried at different temperatures in two parallel ducts. It would be an advantage to have closed loops formed by the ducts, so that there are two paths for air at any point. In this way a change in demand can be handled without causing excessive disturbance in the friction drop of the ductwork. Mixing boxes connecting to two ducts would draw air from each as determined by thermostats operating controls at the mixing box.

Avoid sounds being carried through ducts

Because good hearing conditions are mandatory in all of the learning spaces, it is imperative that great care be taken in laying out ductwork and in selecting fans, blowers and other equipment. Ducts must be located and routed to avoid carrying sounds from room to room. This will be a matter of particular concern where amplified sound can be carried readily and distinctly through ductwork. If a double duct mixing-box system is used, individual runs from the box should be lined with sound-absorbing material. This is a most important caution.

Isolate equipment

In selecting the mechanical equipment itself, the rated noise levels should be carefully examined and verified, to insure that the noise introduced into the learning space from this source will not exceed the desirable masking level. In most cases this will necessitate locating the equipment at some distance from the rooms it serves, where it can be acoustically isolated, and if necessary, lining the connecting ducts with sound-absorbent material to minimize sound transmission.



3 ENVIRONMENT FOR MEDIA: FURNITURE

Planning furniture an integral part of the design process

For effective uses of media in education, the manner which classrooms, seminar rooms, independent study facilities and other learning spaces are furnished is an important design decision. Unfortunately, too often the selection and purchase of furniture are left until too late in the planning process when energies, funds and professional services have been expended. Furniture, as part of the learning environment, should be considered an integral part of any space in which media are to be employed; its selection should be based on careful study and professional advice early in planning. Most importantly, functional, aesthetic, and economic criteria should be established during the programming stages when the functional requirements of the spaces are spelled out.

Fixed seating – continuous counters with fixed seats

Many types of seating for learning spaces are available, but their individual appropriateness varies from space to space. Of the three basic types of seating (fixed, moveable, and combined) fixed has had the advantage of guaranteeing that, once properly positioned, every student will always be in the proper relationship to screens and other display surfaces. Of the various types of fixed seating, the continuous counter with individual fixed chairs provides a desirable surface for writing and for holding references. This is particularly important in secondary and higher education where the learning process may require extensive use of various types of materials and resources during a class. Also, a continuous counter works well when portable, audio-visual equipment, small demonstrations, or various forms of teaching machines are to be used by students at their seats, or when student response systems, requiring the use of a response panel at each station, are to be installed initially or planned for later installation. This type of seating does require more floor area per unit than most other types of fixed seating, but this may be compensated for by the provision of cross-aisles between each row of seating, allowing students to move freely to and from their seats.

3 / FURNITURE

Fixed seating – theater types

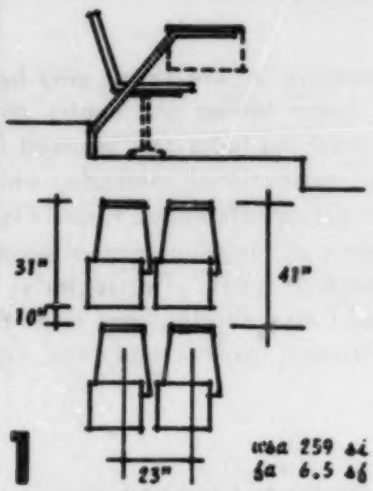
There are many so-called "theater-type" of fixed seating employing a seat with a folding or lifting individual writing surface. Unfortunately, many of the tablet arms provided with this type of seating have the disadvantage of being too small to accommodate writing and reference materials. Lately, some improvements in seating have resulted in folding tablet arms that are adequate in size. Generally, fixed seating of this kind requires less floor area than the continuous counters, but student access to his individual seat is more limited. Also, the necessary moving parts to raise and lower the tablet arms can create maintenance and upkeep problems. Installation of response devices and outlets for equipment can be handled in seating with moveable tablet arms, but this again introduces maintenance problems.

Moveable seating

Moveable seating also introduces a variety of alternatives, and again the provision of an adequate writing surface is extremely important. In rooms where regrouping of students is important, separate table units or seat-table units that are modular to allow conference and discussion groupings are deisrable. Moveable seating mitigates against the use of any individual student instructional device requiring wiring such as response systems, portable recorders or projectors, and power operated teaching machines. Particularly with moveable seating, seating should be scaled and designed with the age and character of the students in mind.

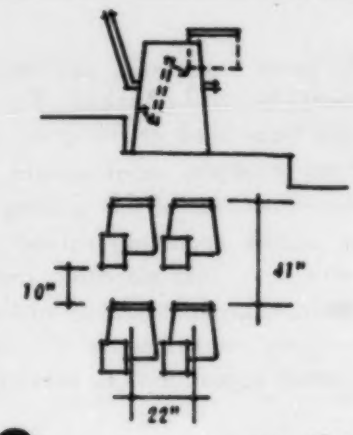
Combined seating

Combined seating is basically of one type–continuous counter with loose seats. This type has the advantages of flexibility, accommodation to many body postures, and reduced cost over the continuous counter with fixed seats. However, for continental seating, the interpretation of building codes may prohibit this type of seating in large rooms. The accompanying diagram illustrates several of the fixed and combined types of seating that are available, together with the average size of writing surfaces and the floor area required.



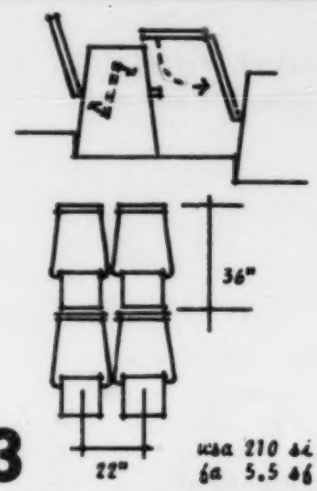
1 wsa 259 sf
fa 6.5 sf

fixed seat & movable tablet arm



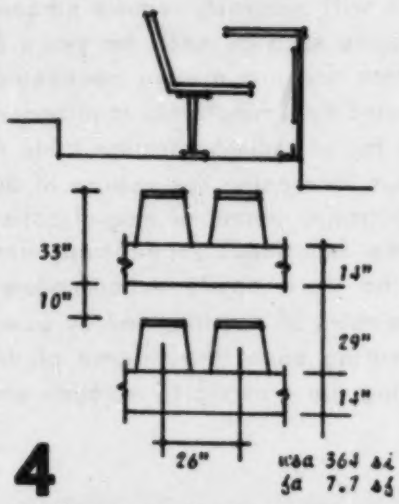
2 was 98 sf
fa 6.3 sf

theatre seat & drop tablet arm



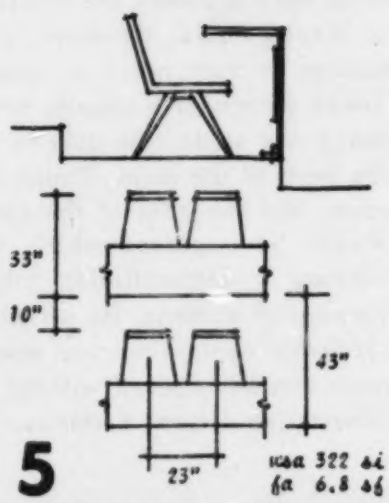
3 wsa 210 sf
fa 5.5 sf

theatre seat & drop counter



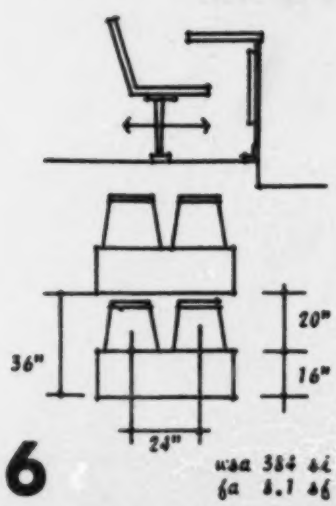
4 wsa 364 sf
fa 7.7 sf

continuous counter & pivoted seat



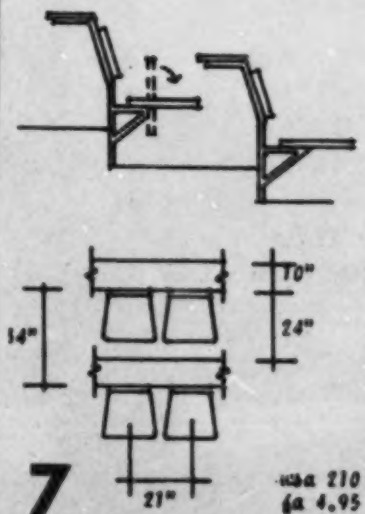
5 wsa 322 sf
fa 6.8 sf

continuous counter & loose chairs



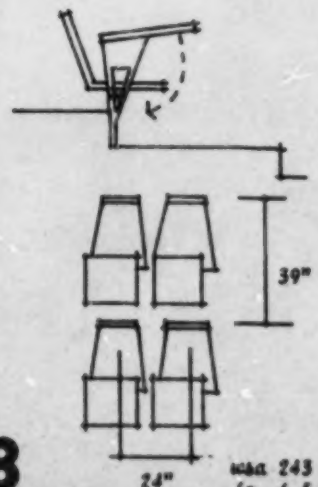
6 wsa 384 sf
fa 8.1 sf

2-man counter & adj. pivoted seats



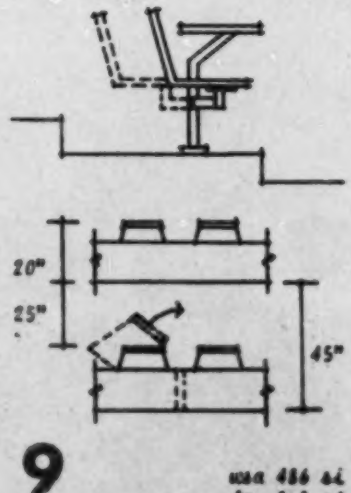
7 wsa 210 sf
fa 4.95 sf

seat-back counter & folding seat



8 wsa 243 sf
fa 6.5 sf

fixed seat & drop tablet arm



9 wsa 486 sf
fa 8.1 sf

continuous counter & cantilever seat

wsa – writing surface area
fa – floor area

SEATING TYPES

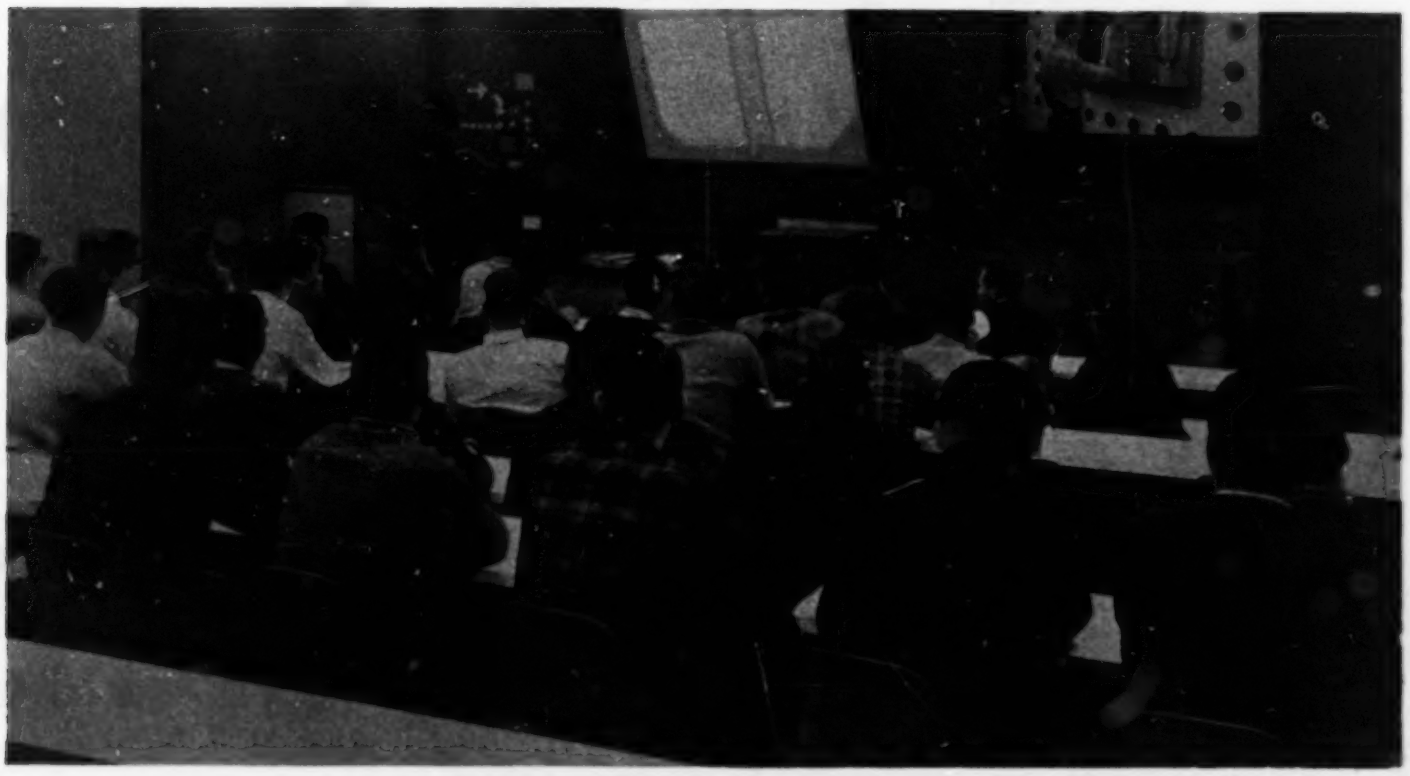
3 / FURNITURE

A mix of seating is often the answer

In many instances, several types of seating in one space may best meet functional needs. For instance, loose tables and chairs on a flat floor area at the front of a large teaching room can be used for case studies, moot courts, and other instructional methods, while the remainder of the seating is fixed on a sloped/stepped floor. Also, in rooms requiring raised seating, rows of seating may alternate between riser-mounted and floor-mounted types. Particularly in medium group spaces, various types of loose seating may meet the varying requirements dictated by multi-age, multi-class, and non-graded approaches to learning.

Importance of good sight lines from all seats

Certainly in rooms where projected media are to be used extensively, good sight lines from all seats to all screens are important. Where 40 or more students are involved, this will generally require stepped or sloped floors. However, steep slopes such as seen for years in college lecture halls or amphitheaters are not always necessary. These slopes have usually been dictated by a functional requirement that every student be able to see the top of a demonstration table at the front of the room. Rather than thus increasing the volume of the room, and the cost of the room, electronic means of magnification should be employed which shifts the functional requirement from viewing a demonstration table to the more easily accommodated viewing of screens. By offsetting the rows of seating, and by using platforms containing two rows of seating each, the volume of the room can be reduced without impairing the viewing of screens and information display surfaces.



Investigate the the advantages of continental seating

In laying out seating in the larger rooms, continental seating which allows cross-aisles between the rows of seats, should be explored. This arrangement can move aisles outside the viewing area, can allow longer rows of seats, and can permit students to move to and from their seats without disturbing other students. The square footage per seating unit based on the total room area may not be much greater than that for more conventional arrangements. Each such solution must be judged in accordance with the applicable building code.

Criteria and the method of selecting seating

The selection of seating for each space in an educational building requires the early development of specific criteria against which each alternative is judged. The following outline of criteria may be helpful:

- functional values--writing surface, book storage, comfort and posture, adjustability, accessibility.
- structural values--durability, simplicity of construction.
- ease of cleaning.
- economy of space.
- appearance
- cost

In conjunction with these criteria, a rating method for comparing various seating types was established and is described in the following chart.

CRITERIA FOR SEATING

FUNCTIONAL VALUES

Visiting surface: points for size and convenient location of surface. Surfacing material considered in comparing alternate designs:

maximum score.....14 points
minimum score..... 6 points
no surface at all..... 0 points

Unit storage: points for adequate and convenient space in addition to visiting surface:

maximum score..... 5 points
minimum score..... 2 points
no storage at all..... 0 points

Adjustability: points for being able to adjust relation between visiting surface and seat, and seat and floor; adequacy of option and lock-down:

maximum score..... 6 points
minimum if ample option but no adjustment..... 3 points
minimum score..... 0 points

Accessibility: ease of occupying and vacating seat and using visiting surface without stabbing neighbors:

maximum score..... 9 points
minimum score..... 3 points

STRUCTURAL VALUES

Durability: points for strength, ruggedness of design, stableness of item delivered, considerations to owner:

maximum score.....12 points
minimum score..... 0 points

Mechanical simplicity: points for lack of complex mechanisms and moving parts which increase costs of maintenance and repairs:

maximum score.....12 points
minimum score..... 3 points

EASE OF CLEANING

Cleaning floor: points for minimum obstructions of supports or attachments with cleaning the floor:

maximum score..... 7 points
minimum score..... 0 points

Cleaning other unit: points for minimum time and effort required for cleaning seat and visiting surface:

maximum score..... 5 points
minimum score..... 2 points

ECONOMY OF SPACE

points for smallness of floor space required per unit:

maximum score.....10 points
minimum score..... 4 points

APPEARANCE

points for cleanliness and attractiveness of the design:

maximum score.....12 points
minimum score..... 0 points

COST

points for economy of installed unit:

maximum score.....12 points
maximum, if in normal used range..... 3 points
maximum, if substantial... 0 points

Selection of other furniture types requires careful analysis and search

Besides seating, many other kinds of furniture must be designed or selected to complete the furnishings of a learning environment with media. Again, these decisions should be made early and with professional help, the furniture should be considered as an integral part of the space, and the selection should be based on established criteria of function, aesthetics and cost. Storage cabinets, work counters, work areas with utilities, laboratory equipment, teachers stations and lecterns, and many other types of special furniture may be custom designed and built for the particular job, or may be picked from stock, catalog items. In any case, a modular approach based on a dimensional system should be encouraged to simplify detailing and to permit rearrangement of the furniture elements. It would be impossible to review here all the types of furniture involved; it is strongly recommended that an extensive search and review of all available types be made before making final selections.

Media module as a piece of furniture

One new type of furniture that may be considered in small and medium size rooms is the self-contained cabinet for media—a "media module". There, projector, screen, mirrors and controls are fitted together to form a projection system inside a cabinet; the total unit may be fixed, portable, or a combination of fixed cabinet and portable projector. The media module has been described in detail in Report B; here it should be recognized as one more kind of furniture that should be considered and which can introduce media in new or remodelled facilities.

Independent study units

One major category of furniture should be further mentioned. Independent study units will be found in resource centers and classrooms, and will be related to many other types of spaces. As has been stressed before, these units may be of many types ranging from simple, but comfortable, tables and chairs to complex carrels which provide for the reception of audio and video information. Included are many types of simple study carrels and even comfortable lounge chairs for "soft reading". Often, a mix of all these types will best meet functional needs of an educational plant.

Simple carrels may be best

Student study carrels often seem to be more elaborate and more expensive than functional needs require. Simple carrels may be provided now which can be modified later to permit electronic reception of audio and video. Finally, experimental or mock-up carrels can be designed and built locally for trial and evaluation before a large investment is made in the final answer. The whole field of independent study is undergoing such extensive study and change that a large investment in one solution now may not be appropriate.

4 HARDWARE FOR MEDIA: PROJECTION SYSTEMS

Importance of designing systems

Too frequently the hardware used in audio-visual presentations is regarded as a collection of individual items—a projector, a screen and a speaker—each performing its function more or less independently. A much broader concept is essential if media are to be used with maximum effectiveness. Not only these hardware items, but also the seating area and the environment itself must be considered as integrated components of a system, each influenced by, and depending on all of the others in producing the total effect. None of these components, even the hardware, can be selected on its merits alone.

Four factors influence viewing conditions

Regardless of the projected material or method, the effectiveness of the presentation depends upon the ease with which the viewers receive the message. With any normal audience, the quality of viewing conditions is chiefly determined by four factors:

- the appropriateness and efficiency of the projection equipment and screens
- the quality of the projected material
- the location of the viewer in relation to the screen
- the visual and auditory environment

Objective of this section

The chief concern here is to outline the interrelationships and major considerations affecting the choice of the projection hardware—projector, screen and controls—and to discuss briefly certain criteria for projected materials, and how the optimum viewing area is determined. The visual and auditory environment has been discussed previously; only its influence on the design of projection systems will be covered here.

4 / PROJECTION SYSTEMS

FRONT AND REAR PROJECTION

Two types of projection...

Before considering any of the above matters, it is important to recognize that two *different* methods may be used for projecting images onto a screen, and that the choice of method will influence the design of a projection system. These two methods are:

- Front projection, in which both the projector and the viewers are on the same side of an opaque screen which reflects the image, and,
- Rear projection, in which the projector and the viewers are on opposite sides of a translucent screen upon which the image is displayed.

Both methods are employed in the studies presented in Report B. Either one may be used for any type of projector, including the TV projector, but customarily the overhead and opaque projectors are used only in front projection.

...and their advantages and disadvantages

Both front and rear projection have their inherent advantages and disadvantages, which become clear by comparing them in respect to the most important areas of difference. These are:

- the effect of ambient light,
- space requirements, and
- interference with the projected image.

Rear projection allows higher light levels

The ambient light level in the room is much more critical with front projection than with rear projection. This means that with present equipment a much higher level of room lighting can be tolerated in the viewing area when rear projection is employed. This is considered to be the *chief* advantage of rear projection, particularly in larger rooms. In rooms where small image sizes are appropriate, ambient light effects may not be critical providing proper equipment is used. Current developments in the improvement of equipment indicate that the size of acceptable images possible with front projection under useful levels of ambient light will be increased.

More space for rear projection

An undeniable disadvantage of rear projection is that additional space behind the screen must be provided to accommodate the projectors and their throw distances. To conserve space, projectors with short focal length lenses are desirable and mirrors may be used to "bend" the projection rays. Also self-contained screen-projector

units or media modules may be used. It must be recognized, however, that shortening the focal length of the projector decreases the width of optimum viewing areas, and the use of mirrors generally diminishes the effective brightness of the projected image.

No problems of interference with rear projection

One of the important advantages of rear projection is that the projection rays are protected from interference by either the instructor or the viewers. The instructor can stand in front of the image to point out details without casting shadows. With front projection this is impossible; distracting shadows are cast by any object or person in the path of the projection beam, and the freedom of the instructor is limited accordingly.

Other factors

It has been assumed that in both methods the projectors are located in reasonably soundproof enclosures and that remote control is provided for the instructor who remains at the front of the class. Such assumptions are frequently not valid for front projection, however. With relatively small groups of viewers, portable front projection equipment is often used, and the instructor himself may operate the projector. Used in this way, front projection has several additional disadvantages which should be recognized. Unless precautions are taken to minimize it, the noise of the projector is distractive to viewers, and if the instructor must double as an operator, his effectiveness as a teacher is necessarily diminished.

SCREENS

Screen type important for visual comfort

The design of any projection system must necessarily recognize "the human factor"—the needs and limitations of the observer. The impact and effectiveness of the image displayed largely depends on such matters as its brightness, its legibility and its contrast values.

4 / PROJECTION SYSTEMS

The human eye can tolerate and adjust to a remarkably wide range of conditions, but if eye strain is to be avoided, these critical variables must be controlled within established limits of acceptability. The projection screen is a major component in determining visual comfort.

A variety of screen types are available for both front and rear projection. They differ significantly in their characteristics, affecting both the appropriate size of viewing area and the tolerable level of ambient lighting.

Types of front projection screens

For front projection, four types of opaque reflective screen are in common use:

- *Matte screens*, which have non-glossy, non-directional surfaces that appear to have essentially the same brightness from all points within the viewing area, and hence a relatively wide viewing angle. In addition to the flexible variety, fiberboard or plaster walls, finished with a flat white paint may serve as matte screens, although they will lack brilliance.

- *Beaded screens*, which have white surfaces coated with fine glass beads that reflect light toward its source. This produces a bright image over a rather small maximum viewing angle.

- *Lenticular screens*, whose surfaces have very small parallel lens-like serrations that serve to control light reflectance so as to produce maximum brightness over a specified maximum viewing angle. Some types provide a uniformly bright image over an area comparable to that provided by a matte screen.

- *Metallized screens*, which are coated with paint having a metallic pigment. These screens may be highly directional, resembling the beaded screens, or their characteristics may be more like those of matte screens. The more specular ones may have undesirable "hot spots" due to reflection.

Rear projection screens

Rear projection screens are necessarily translucent. They serve to accept incident illumination from the projector, and to diffuse and re-radiate it as a visible image. They may be either flexible or rigid, and in both cases, have a roughened surface similar to ground glass to provide diffusion. A variety of screens with widely differing characteristics are available.

Characteristics of screens

With either projection method, each type of screen has its unique properties. It is essential that the appropriate type be chosen in each situation, and to aid in making a selection, some knowledge of screen characteristics is needed. The more important of these characteristics are identified and defined in the following paragraphs, with brief summary explanations of their effect on the projection system. Unless otherwise stated, these characteristics pertain to front and rear projection screens alike.

Viewing Angle: The angle used in referring to and evaluating screen characteristics as observed at different locations in the viewing area. It is defined as the angle described at the center of the screen, by the viewer's sight line and the projection axis. Excessive viewing angles will result in reduced brightness or distortion. The maximum viewing angle at which distortion becomes objectionable is about 50°. The maximum viewing angle limited by brightness and contrast will vary with screen and projector and may be as narrow as 20°.

Edge Angle: The angle defined by the surface of the screen and a line from the viewer to the far edge of the screen. Too narrow edge angles will result in distortion and inadequate image brightness. (Either edge angle or viewing angle can be used to define the sides of an appropriate viewing area; in these reports, the former method is used.)

Bend Angle: Another reference angle used in evaluating rear projection screens. It is the angle described by the outermost light ray of the projector and the sight line of any viewer. The maximum bend angle is that angle beyond which the amount of light reaching the viewer is inadequate and will not produce an acceptable image. A limited number of rear projection screens available today are capable of achieving satisfactory images with bend angles in excess of 50°. (This angle is also critical in determining the maximum width of the seating area).

Screen Brightness: This is the measure, in foot lamberts, of the light intensity observed on the screen--reflected light on a front projection screen and luminous intensity on a rear projection screen. Brightness is independent of viewing distance, but varies with the viewing angle. It is fundamental to the production of a good image. Without adequate brightness, color, contrast and detail are lost. It is also a critical factor in establishing the permissible level of room lighting during projection. Screen brightness is determined by the light output of the projector, the size of the image, and the reflecting or transmitting properties of the screen itself. A small image will have four times the screen brightness of an image of doubled dimen-

sions (quadrupled area) produced by the same projector at twice the throw distance. Thus, to retain acceptable brightness, other factors remaining constant, the larger the image desired, the more powerful the projector required.

In small spaces the brightness of a 2- or 3-foot image, even with front projection (and an appropriate screen) may be sufficiently high to be clearly seen under subdued daylight, but in larger spaces requiring larger images, adequate brightness is obtainable economically only by rear projection. This is because a front projection screen is designed to reflect all light including ambient light, and the reflection of room ambient light increases the non-image brightness thereby reducing contrast. A rear projection screen may reflect as little as 5% of the ambient light striking it, thus greatly increasing contrast and clarity of image.

Several authorities have recommended appropriate screen brightness levels for various projected media. Most of these recommendations, however, are based on darkened room conditions, whereas in educational applications, the provision of some room lighting is essential. Consequently, the authors feel that because of certain important differences, the professional standards are not necessarily always applicable to educational requirements. As the result of considerable experience with educational projected media, and a comprehensive study of screen characteristics, it is recommended that for practical purposes, the minimum acceptable brightness of screens for school use should be 5 Ft. L. when films or slides are shown, and not less than 2 Ft. L. for projected TV. (See "Standards") It should be emphasized that the lowest values are marginal values and apply to the poorest seat in the viewing area. All other seats will have better viewing. Higher values are, of course, desirable if economically feasible.

Brightness Ratio: The ratio between the maximum and minimum screen brightness, at different parts of the screen, as seen from a given observation point. The theoretically ideal ratio would be 1:1, but actually, variations within a certain range are not detectable by the normal observer. A ratio of 2 or 3 to 1 is very good. As the ratio increases to 10:1, observers will readily detect "hot spots".

Image Brightness: Screen brightness measured in Ft. L. with the projector operating to project light only, with no slide or film in the aperature (see Contrast Ratio).

Non-Image Brightness: Screen brightness measured with the projector operating, but with the lens capped, and with room lighting at the level normally used during projection images. It is measured in foot lamberts (see Contrast Ratio).

Contrast Ratio: The ratio of image brightness to non-image brightness, as seen from any given observation point. (It differs for almost every position in the viewing area). Since non-image brightness determines how black the darkest portion of the image can be, Contrast Ratio is the relationship between the lightest possible portion to the darkest possible portion of the image.

Ambient room light falling on the screen affects image contrast, and the maximum contrast ratio obtainable is largely determined by the level of lighting desired in the room. To obtain adequate task lighting and at the same time a high contrast ratio requires a correspondingly high level of screen brightness. With less-than-adequate projector output, either the level of ambient light striking the screen must be reduced or a lower contrast ratio must be accepted.

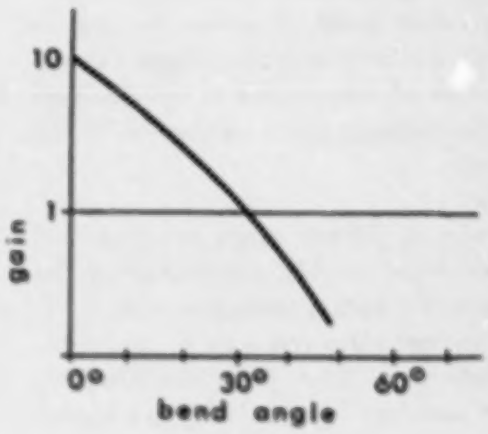
The desirable contrast ratio varies with the type of material being shown. It can be relatively low (5:1) for black-and-white line drawings, but should be much higher (as high as 100:1) for color having a range of intermediate values. A ratio of 30:1 is marginal for color material.

Screen Gain: The ratio between the observed brightness of the screen at any point on the screen, and its actual illumination (by the projector) at that point. Its measured value always varies with the viewing angle, and is determined in different ways for front and rear projection screens. For front projection screens, screen gain is defined as the ratio between the intensity of light reflected by the screen from the projector, and that reflected from the same point by a pure magnesium carbonate target. For rear projection screens, it is simply the ratio between the brightness on the viewer's side of the screen (measured in Foot-Lamberts) and the incident illumination at the same point on the projector side (measured in Foot-Candles).

$$\text{Gain} = \frac{\text{output (Ft. L.)}}{\text{input (Ft. C.)}}$$

Since the screen is a passive element, it can, of course, produce no overall net gain; gains in some areas are offset by compensating losses in others. There is actually, in fact, an overall loss, varying with the light transmission or reflectance efficiency of the screen, which is never 100%.

Gain characteristics of screens are always of prime importance, because gain largely determines the quality of image in respect to viewer location. Screens referred to as high gain screens concentrate the light output of the projector along a very limited cone, thus restricting viewing angles and areas but permitting a high level of ambient light. Low gain screens diffuse light across a wider cone, but suffer a corresponding loss of brightness and produce images with less contrast tolerating less ambient light.



Gain Curve: A graph representing the screen gain over a range of viewing angles.

Beaded screens which have the highest gain factor of any of the front projection types have a correspondingly low maximum viewing angle of about 20°. Matte screens, on the other hand, have lower, but much more uniform gain characteristics, with a wider viewing angle; lenticular screens can be designed for a range of viewing angles. The gain characteristics of rear projection screens vary a good deal, and the range of their maximum viewing angles is generally greater than those of the front projection screens.

An ideal screen would have a gain of about 3 to a bend angle of 60° and then fall off sharply.

Screen Reflection Factor: This is a term used in reference to rear projection screens to identify the proportion of ambient light falling on the screen that is reflected by the screen to an observer. The lower this factor, the better will be the contrast ratio (and image clarity) at a given ambient light level.

The reflection factor is an important consideration in all learning spaces where room lighting level is to be suitable for note-taking. The lower this factor is, the higher can be the ambient light without seriously affecting the image. A screen reflection factor of 5% would be ideal, but factors as high as 35% must occasionally be tolerated in order to obtain sufficiently high gain values at bend angles in excess of 50°. A low factor is obviously undesirable on a front projection screen, because high reflectivity is the basic requirement of such screens. With the rapid improvements being made in screen design, however, it seems likely that screen brightness (and contrast) may be improved to such an extent that the reflection of ambient light may be much less critical, at least in the smaller screen sizes.

All of these characteristics should be considered in determining the appropriate type of screen for a given situation. Obviously, they are inter-related, and the relative importance of each depends on many factors, not the least of which is the type of material being shown.

Interrelationships among these characteristics

If only black-and-white line drawings were to be projected, or if a screen were to be used exclusively for showing 16mm color travelogue movies, or used only for TV projection, optimum values for the various characteristics could be established. But in the learning spaces, such specific and exclusive uses will rarely if ever be encountered. Instead, the screens in these spaces normally serve for projecting the widest possible range of material. Consequently, and also because of wide variations in other critical factors, the selec-

tion of the right screen necessarily involves the weighing of advantages and disadvantages, and intelligent compromise. In most cases, the most important considerations are screen gain, contrast ratio, and the maximum viewing angle over which a clear image can be easily seen.

PROJECTORS

A caution

The reader is cautioned that any discussion of projection devices can only report on the existing ranges and characteristics of commercially available equipment. Technological developments can render much of today's equipment obsolete; at the time equipment is selected, the newest models should be investigated for improvements in optical systems, lumen output, remote capability, ease of operation, and cost.

Overhead projector

The overhead projector currently is one of the most popular projection devices in classrooms. Ease and speed of transparency-making, high lumen output, elimination of the need for room darkening and ease of operation are among its good characteristics. The only special requirement for this projector is a tilted screen in order to prevent keystoning of the image. Projectors range from fanless desktop models to those which include the projection of slides and filmstrip through the projector's optical system. Prices range from $150 to $1000, and lamp wattages are available from 300 to 1000 watts.

35mm slide projector

The classroom use of 35mm color slides has substantially increased with the production of inexpensive, foolproof 35mm cameras and remotely controlled projectors. With the low cost of slide production and the space savings in storage, the 35mm slide is being used more and more extensively than the 3-¼" x 4" slide. For efficient use in classrooms, the projectors should be capable of remote on-off, forward-reverse, and focus. Ideally, the fan should have a thermal device to allow cooling of the projector after the lamp is turned off. Highly desirable characteristics for a projector will be ease of loading, low cost of slide trays that accept all sorts of mountings, and freedom from jamming. Lenses are available that will allow projection from as short a distance as 1W (1 width of the screen) for rear projection to 6W for front projection in larger auditoriums. With improvements in lumen output, mirrors can be used to reduce the space required for rear screen projection. Projectors are available with xenon light sources, random access, digital readout and audio projector programming. Lamp wattage ranges from 300 to 1200 watts and prices range from $100 to $6000.

4 / PROJECTION SYSTEMS

2-¼" x 4" slide projector

Most 2-¼" x 4" slide projectors manufactured today are of the manually operated type. For the purpose of this report and where remote control of the projection device is necessary, the few remotely operated projectors currently available are discussed. Some of the most desirable characteristics of these projectors are high lumen output, the capability with an adapter of projecting 35mm slides, the ability to handle polaroid slides, and short-throw lenses for rear screen projection. Prices for the remote-controlled projectors range from $1500 to over $3000 with wattages of 3000 and more.

Motion picture projectors

Currently the 16mm projector has a monopoly on motion picture projection in the classroom. However, with the introduction of the new, large frame 8mm film and sound cameras, there may be a marked change-over to 8mm for small group use and it will be introduced for independent study. Film projection using 35mm film has never found extensive educational application.

It is desirable for optimum use that the motion picture projectors be remotely controlled for on-off, step frame and focus. Also, some method must be devised to prevent film burns when the projector lamp is turned off, such as delay on the fan circuit or a thermal delay. Industry is trying to make it easier to thread motion picture projectors; perhaps the most promising development is that of the film cartridge-loaded projector. In order to use a motion picture projector for rear screen projection, the image must be reversed. This may be handled using a tank prism, a mirror (first surface if close to the projector), or a lens with an internal mirror or prism. In general, the smaller the aperture, the more lumen output required to obtain a specified image brightness. However, high lumen output can, in time, affect the color dyes of the films. Lenses are available for throw distances of 1-½W and greater.

Film strip projectors and previewers

The low cost and availability of film strips on almost every subject makes this form of visual aid attractive to many teachers. Projectors

with remote control are required for rear screen projection. Single film strip previewers may adequately serve the student studying independently. In between, are projectors appropriate for front projection with small groups. Projectors vary in price from $60 to $300 and previewers from $15 to $30. Lamp wattage range from 150 to 1200 watts.

Television projectors

Television projection has its greatest implication for large group instruction. Its use as a method of displaying and magnifying process images is excellent. Its promise as a first rate teaching tool is dependent, not only on its ability to have good contrast, brightness and definition, but also simple maintenance. Projectors are available for closed circuit or broadcast in either black and white or color and black and white. In general, the more expensive the projector, the more acceptable the image and the higher the lumen output. Projected television requires slightly more than a 2W throw distance. Prices vary tremendously from $2000 to $30,000 or so.

More information

For more comprehensive information on projection equipment the reader is directed to the Audio-visual Equipment Directory, National Audio-Visual Association, Inc., 1201 Spring Street, Fairfax, Virginia.

Space for rear projection

In designing for rear projection, one of the problems the architect faces is the allowance of the correct amount of space for the location of the projection equipment. Figure 1 shows a projector located at a 1W throw distance and indicates the maximum bend angle for seat A as over 75°. This is unsatisfactory for this seat; the allowable bend angle is established by the screen characteristics, and at present, the maximum bend angle is 60°. Figure 2 shows a 2W throw distance and a maximum bend angle at seat A of about 60° which is satisfactory. Figure 3 shows a total depth of rear projection area as 1W, but by using a mirror, still permits a 2W throw distance and a 60° bend angle.

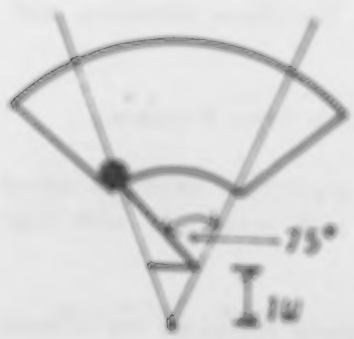


FIGURE 1

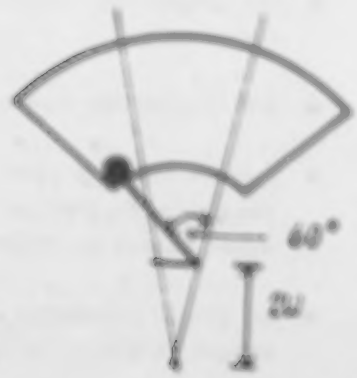


FIGURE 2

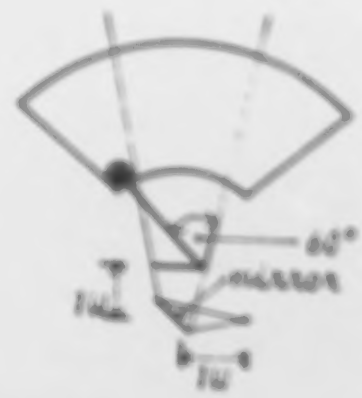
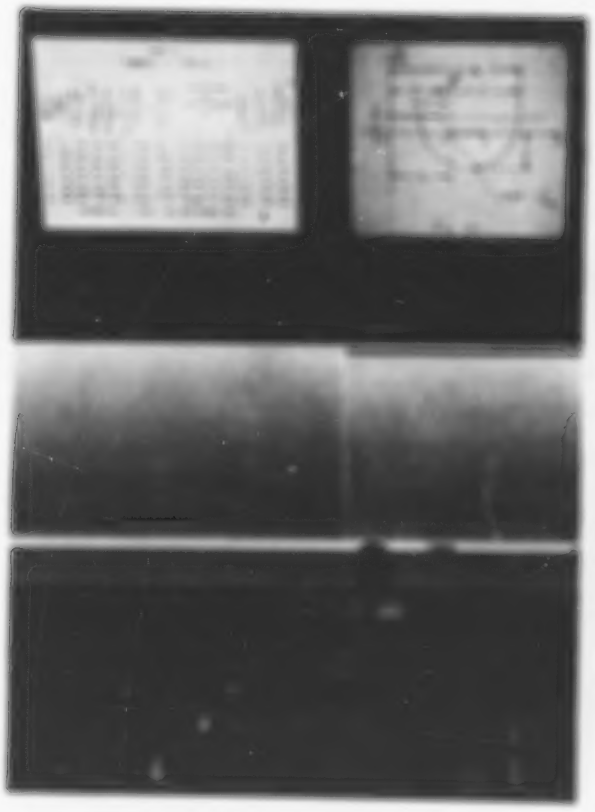
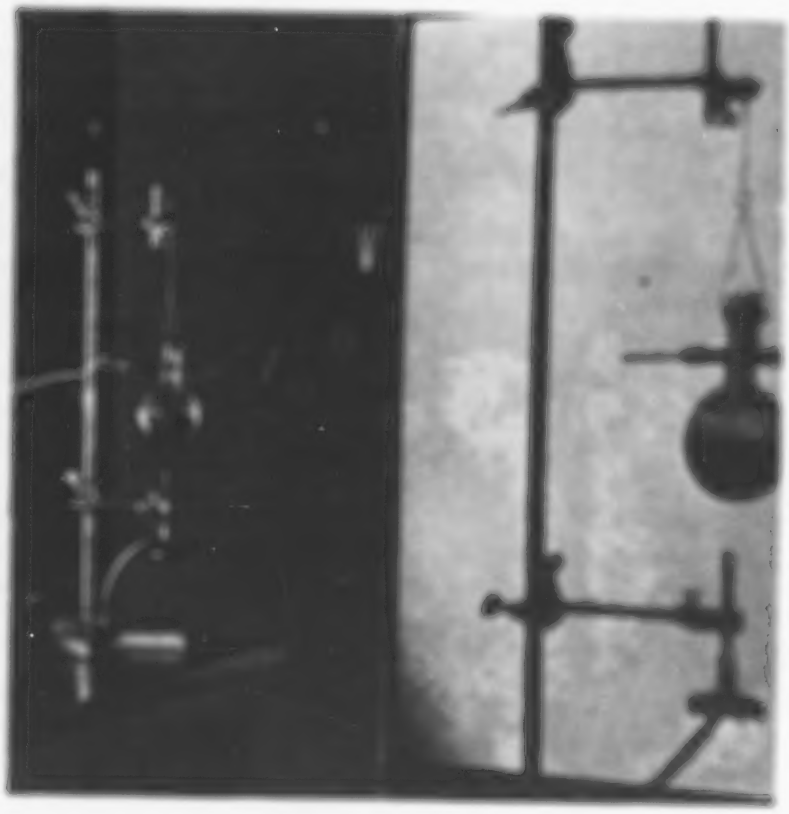


FIGURE 3





Mirrors reduce light

The use of mirrors, however, has its drawback in that about a 10% loss of image brightness occurs. One must also be careful of reflections of ambient light of other projectors or classroom light passing through other screens and effecting either the mirror or the screen. This can be combatted by locating black drapes to mask the projectors from this stray light.

Some general rules

A few general rules are helpful in locating projectors and establishing space for rear projection equipment:

- the larger the screen, the longer the throw distance, and conversely,
- the smaller the screen, the shorter the throw distance.
- mirrors may be used to fold the projection beam for space saving with smaller screens or with projectors with high lumen output on larger screens.
- for initial schematic design a 2W depth behind all the screens should be allocated for the rear projection area.
- the use of extra close-up lenses decreases the viewing area, and may result in some distortion around the edge of projected images.

CONTROLS

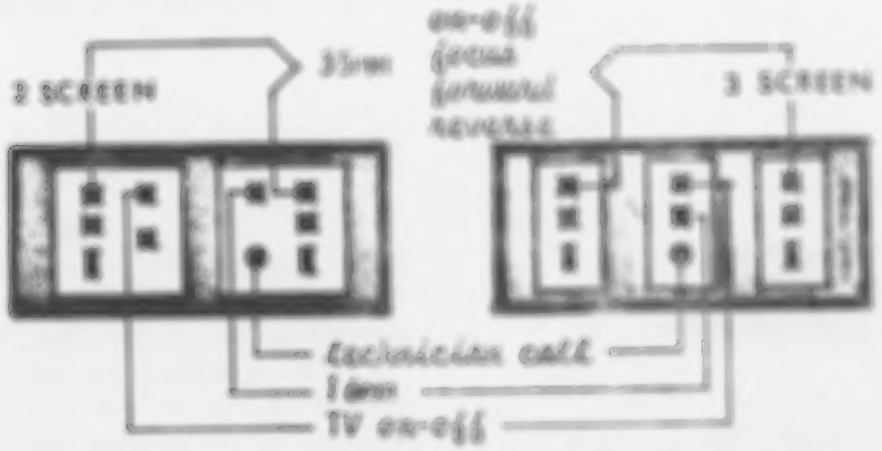
Rear projection equipment remote controlled

Whenever projected media are used, the instructor should be in complete control of the presentation. With rear projection, this necessarily requires remote control. Except in small seminar and conference situations, front projection should also be remotely controlled by the instructor, whether the projector is located in a permanent booth or within the learning space itself. In most cases, several projectors will be used and the instructor, from his lectern or station, should be able to call upon any of them at will. All of the material to be projected must be selected beforehand, arranged in proper sequence and positioned in the projectors. In the smaller spaces, this will probably be the instructor's own responsibility; in the larger spaces, the material will likely be turned over to a technician responsible for loading and servicing the projectors.

Light automatically controlled with projectors

The instructor should also have control of room lighting. This does not mean that the choice of proper lighting levels should be his, but that he should control the change from one predetermined level to another, as the presented media requires. In small spaces this will be done by properly located wall switches, but in other rooms the lighting level should be automatically set at the appropriate predetermined level for each media and controlled by the projector switches. Thus, lighting is controlled by the instructor, but he does not choose the level of lighting used during projection.

Design of the control panel



The diagram illustrates control panels for the use of two or three screens. Note that although these switches do control room lighting, they are not identified as lighting controls. The appropriate levels of lighting are provided automatically as the various projectors are activated, and when no projectors are running, room lighting automatically returns to the "working" level. The controls should be grouped on the panel to correspond to screen positions. For rear projection, or for front projection from a permanent booth, a 3" conduit should be provided between the instructor's station and the projection area to accommodate the necessary wiring.

PROJECTED MATERIAL

Classes of projected material

The Eastman Kodak Company classifies projected material as follows:

Class A: Full-scale continuous-tone black-and-white or color pictures in which pictorial values are important and color or tone differences must be discriminated. Minimum contrast ratio—100:1

Class B: Color diagrams and continuous-tone black-and-white pictures in high key. Minimum contrast ratio—25:1

Class C: Simple line material, such as text, tables, diagrams and graphs, either positive or negative. Minimum contrast ratio—5:1

Importance of legibility standards

Because the contrast requirement for Class C material is relatively low, the importance of the legibility of such material is sometimes overlooked in its preparation, but it is critical. Any projection material containing letters, numerals, or other symbols should be prepared with legibility uppermost in mind. Certain standards have been developed to insure ready perception. If H is the height of the image, then the smallest lettering should be no less than H/30, typical lettering should be H/60 and title lettering H/20.

THE VIEWING AREA

Viewing area not critical in most classrooms

Before projected materials were introduced, the objects to be viewed in the usual schoolroom were the instructor, the chalkboards, and sometimes maps and charts. The instructor was free to move about the room, and the other objects of visual attention were usually distributed over several wall areas. All of them received their illumination by the general lighting of the room itself. With no fixed area of attention, sightlines and viewing were not critical, as long as the general lighting was adequate.

Projected images restrict viewing area

For the effective use of visual aids, however, the requirements for good viewing are much more demanding. The projected image necessarily occupies a fixed position, and, except on the TV receiver, is in a flat plane. Whereas a three-dimensional object may well be viewed from the side, a flat picture can be seen intelligibly only within the limits of a "cone of view". To see the image properly, the viewer must be within the limits of this cone, and neither too

near the image nor too far from it. The area defined by these limits is referred to as the viewing area. Its importance in the planning of spaces for image viewing is fundamental, whether the space be a small informal conference area or a large formal lecture hall.

Shape of the viewing area

The shape of the viewing area, then, is approximately as shown. Its size is always based on the size of the image to be viewed. The human eye comprehends detail only within a limited cone angle (about 2-½ minutes of arc), and the length of chord subtending this arc, e.g. the image width, varies with its distance from the observer. Thus an object 20 feet away and 6 feet long appears the same as a similar object 10 feet away and 3 feet long. The size of the viewing area is determined by three dimensions:

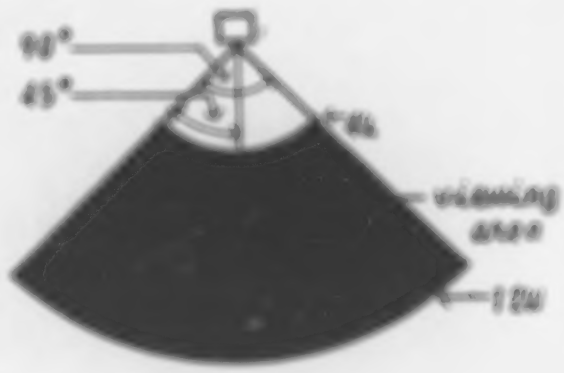
- The Minimum Distance, (1), which is the distance from the nearest part of the image to the eye of the closest viewer,
- The Maximum Distance, (2), which is the distance from the furthermost part of the image to the most distant viewer, and
- The Maximum Viewing Angle, (3), which is the angle between the projection axis and the line of sight of a person located as far from this axis as he can be and still see all image detail in proper brilliance.

Two ways of establishing the viewing angle

Whether the apex of the Maximum Viewing Angle should be located at the screen or at some other point on the projection axis is a moot point. There is some disagreement among authorities, too, as to how it should govern the side limits of the viewing area. Some prefer the use of the "edge angle", while others use the angle at the center of the screen. By either approach, the limits defined are essentially

similar. In this study, an edge angle of 40° has been used in laying out viewing areas for rear projection, since it is felt this best represents average screen characteristics. With front projection, the use of the "center angle" is probably more common practice, and its values range from 20° to possibly as high as 30°, again depending on factors which were explained in the discussion of screens. The maximum value of the angle used in determining the viewing area for receiver TV is 40°.

Size of Tv Tube	min viewing distance 4W	max viewing distance 12W
17"	4'-11"	14'-9"
19"	5'-1"	15'-2"
21"	6'-4"	19'-0"
23"	6'-6"	19'-4"
24"	7'-3"	21'-3"
27"	9'-8"	24'-3"



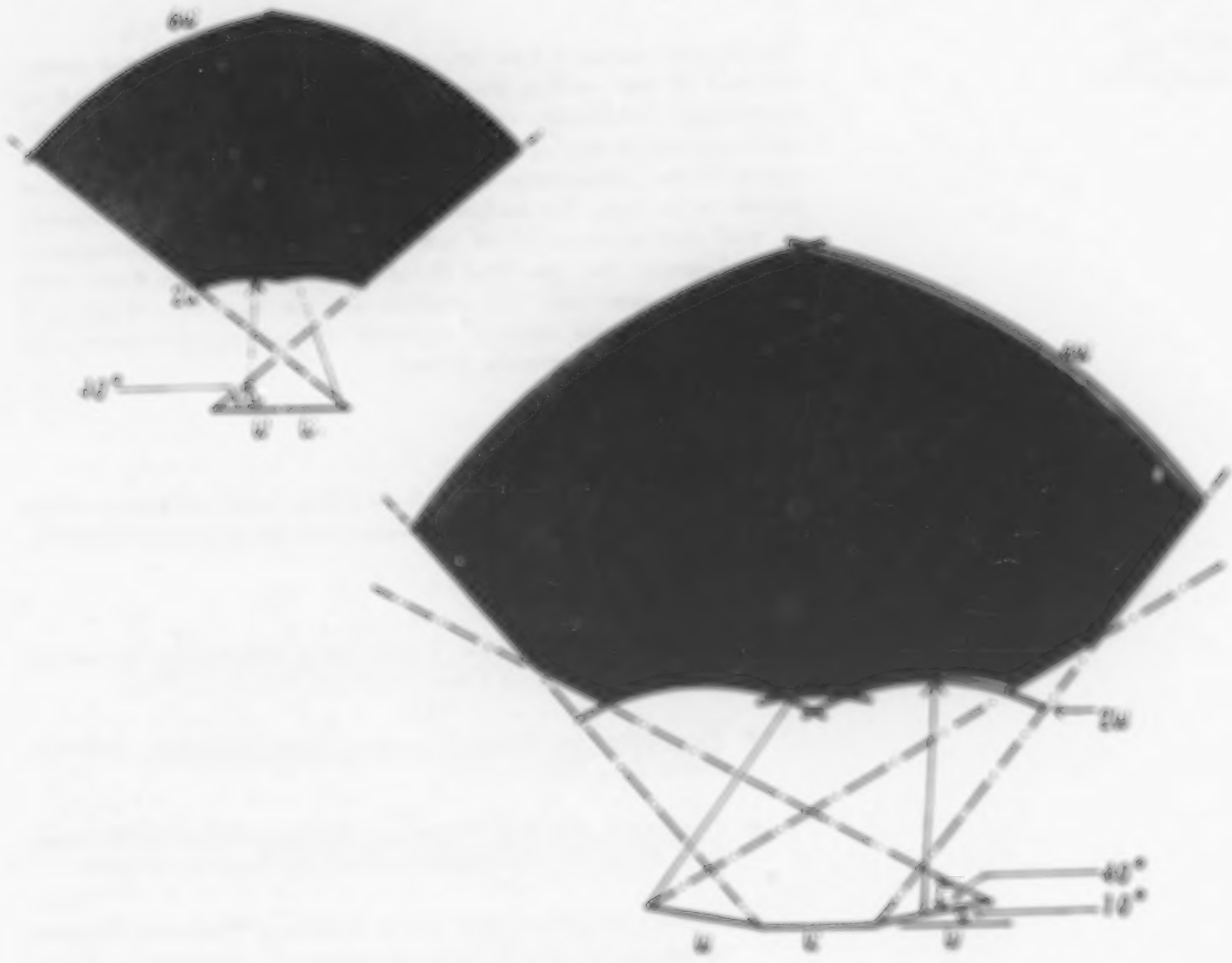
Defining minimum and maximum viewing distances

Practical minimum and maximum distances are both expressed as multiples of the image width (W). They vary both with the medium being used and with the type and quality of material being projected, and may be affected also, in some degree, by personal preferences. They have not yet been precisely determined by scientific methods, and it's doubtful that such data would have much practical value anyway. The generally accepted values, resulting from numerous studies, are these:

	Film, Slides and projected TV	TV Receivers
Minimum distance	2W	4W
Maximum distance	6W to 10W	12 W

Relation of screen size and viewing area

Since the size of the viewing area is a function of the image width, it follows that the proper screen size for any given space will be determined by the number of viewers intended. Conversely, a given type and size of screen automatically establishes the size of the viewing area, and consequently the size of audience that can be properly accommodated. The viewing area is the pattern which determines the seating arrangement in any learning space where projected images are to be effectively used, and in the larger spaces, at least, it also influences the shape of the room.



PLANNING THE PROJECTION SYSTEM

Steps in design

Whether front or rear projection is to be used, the design of the projection system itself involves determining:

a) the size of viewing area required

b) the appropriate screen size

c) the proper type of screen

d) the appropriate projector(s)—the required lumen output, focal length and location

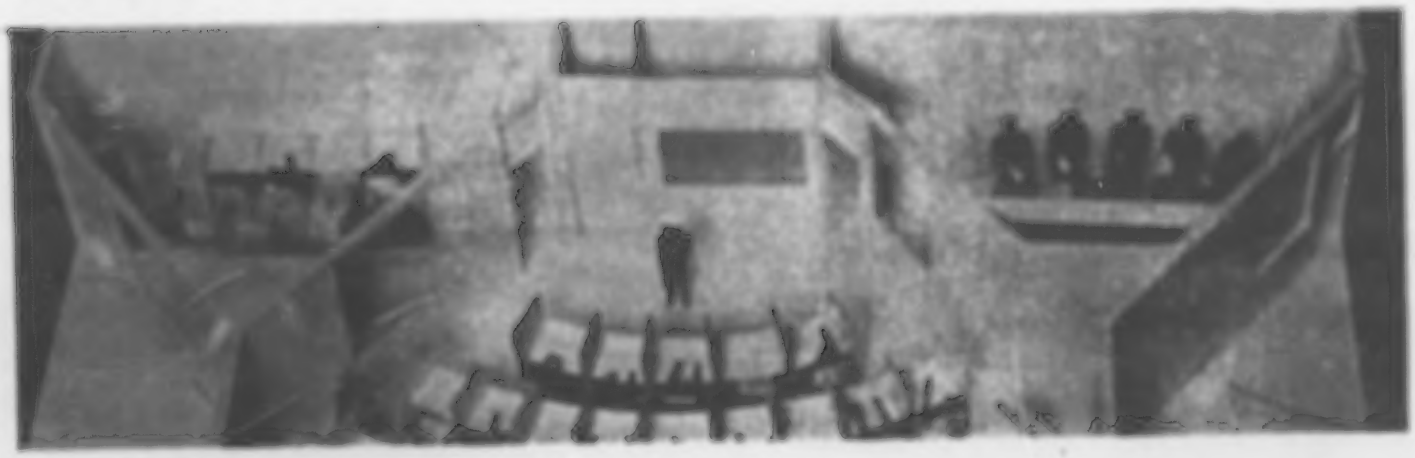
e) the maximum permissible level of ambient lighting on the screen.

Trial and error at first

The desired audience size is usually predetermined. In some cases, the size of the viewing area, too, may be established by existing conditions. Otherwise, its size and shape should be tentatively approximated in accord with the principles already discussed. Because of the relationship between its dimensions and the width of screen to be used, the inexperienced designer necessarily proceeds by trail and error, until he arrives at a satisfactory arrangement accommodating the specified audience in proper relationship with the screen. Sometimes, the problem may be reversed, requiring a determination of the optimum audience and seating arrangement for projection equipment already on hand.

Several helpful brochures and articles have been published which explain in detail the selection of components for projection systems. Among these are

- Space for Audio-Visual Large Group Instruction, University Facilities Research Center, Madison Wisconsin 1963
- Foundation for Effective Audio-Visual Projection, Eastman Kodak Co., 1957
- Components for Rear Projection Systems, School of Architecture, Rensselaer Polytechnic Institute, Troy, N. Y. 1964
- "Effects of Stray Light on the Quality of Projected Pictures at Various Levels of Screen Brightness"; Raymond L. Estes; Journal of the SMPTE; 1953
- "Selection and Specification of Rear-Projection Screens"; Petro Vlahos; Journal of the SMPTE; 1951.
- "Operational Characteristics of Rear Projection;" John F. Dreyer; Journal of the SMPTE; 1959



STANDARDS

Professional standards accepted by the Society of Motion Picture and Television Engineers have been developed for viewing front and rear projected images. These standards provide excellent images. However, for the purpose of economy in classroom use of projected media, it is felt that some standards based on the present cost in the room can be lowered, particularly for gross images. The following values of standards indicated by asterisk (*) those that are less than the professional standards.

Screen Brightness

Motion Pictures:

- 5 Ft.L. = Minimum* (gross images)
- 10 Ft.L. = Satisfactory
- 15 Ft.L. = Excellent
- 20 Ft.L. = Maximum (glisten threshold for some observers)

Slides:

- 0.5 Ft.L. = Minimum* (gross images)
- 5 Ft.L. = Minimum for slides with color
- 10 Ft.L. = Satisfactory
- 20 Ft.L. = Excellent

Projected TV:

- 2 Ft.L. = Minimum* (gross images)
- 20 Ft.L. = Maximum (glisten threshold for some observers)

TV Monitors:

100 lumens per square foot

Brightness Ratio

- 2:1 = Excellent
- 3:1 = Very good
- 10:1 = Acceptable* under some conditions

Contrast Ratio

- 100:1 = Preferred screen
- 25:1 = Good legibility of printed characters
- 5:1 = White letters on black background
- 30:1 = Minimum* contrast ratio for present cost dictated by higher levels of classroom light and many types of projected materials.

Contrast ratio is determined in part by non-image brightness which, in turn, is related to screen reflectance and room ambient light. Therefore, controlling the amount of ambient light reaching the screen is important. For large screen installations, if the amount of ambient light incoming at the screen is held to 1-2 Ft.C., the contrast ratio will normally be adequate.

Working Surface Lighting Levels

Ideally, an average ratio of 1:1 between working surface brightness and screen brightness should be maintained, while not creating excessive ambient light on the screens. Since screen brightness varies for each area in the viewing area, the average combination of brightness for each broad class of projected material should be approximately calculated. For a medium to large size room, these lighting levels would be in the range of:

- 5-10 Ft.C. = Projected TV and films
- 10-20 Ft.C. = Slides
- 30 + Ft.C. = Other close activities

5 HARDWARE FOR MEDIA: OTHER EQUIPMENT

Hardware as a panacea

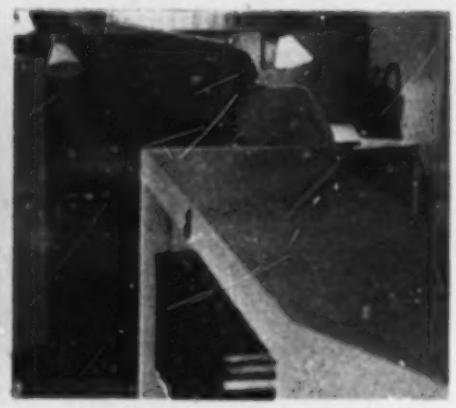
For many years, the educational market was not considered significant by the audio-visual industry; schools had little money for hardware, and what equipment they purchased was developed primarily for home, industry or government use. With the passage of the National Defense Education Act and other governmental and foundation support, industry recognized a vast, new market; the race to produce educational hardware began and educators were engulfed by salesmen whose products were the answer to all their needs. The acquisition of hardware became a status symbol, but unfortunately too little time was spent in planning its incorporation into a total system supporting specified educational objectives. The problem is still with us; the following review of additional available hardware is offered to indicate some of the potential available to education, but which must be employed within the context of purpose and need. Even so, much of what is mentioned will soon be obsoleted by newer, more desirable hardware.

Wet and dry carrels

Current interest in independent study and programmed instruction has introduced a new line of hardware—independent study is often housed in a study carrel, for which there are no standards as to size, shape or location. At present, carrels are designated as either "dry" or "wet". A "dry" carrel will provide writing surface, semi-isolation and storage, and depending upon its location and use, may also provide task surface lighting and an electrical outlet for portable projection and recording devices or teaching machines. The "wet" carrel introduces audio and video into an acoustically treated or totally private carrel. This requires that the designer provide conduit to the carrel from a distribution center.

Teaching machines

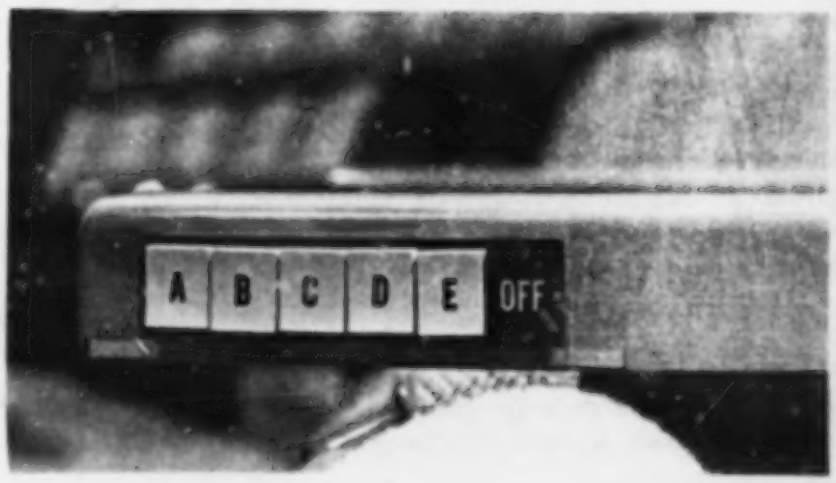
The teaching machine is a vehicle for programmed materials and is generally used in an independent study situation. The size, shape and complexity of these devices vary greatly; the more complicated



ones may use both projected images and audio, while others may merely require the student to view written information and answer multiple choice questions. They are usually portable and may be used on the classroom desk or at a study carrel. The designer is only concerned when these devices need electric or electronic connections; for the most part only 110V AC power is required.

Student response systems

A student response system allows a teacher to immediately evaluate the effectiveness of his presentation. Each student station is equipped with a response unit of 4 or 5 buttons, and a correct answer indicator. The teacher's console contains indicators or meters corresponding to each response button. The teacher poses a multiple choice question and the student presses the button corresponding to what he believes is the correct answer. The instructor can see immediately the percentage of responses to each choice. A record of answers for each student can be made on punched tape or stored in a computer, while the student immediately receives visual display of the correct answer. Of the many response systems available today, most all require wiring from the student station to the teacher's console and power unit. In order to plan for such a system, it is necessary to know the number and location of the student stations and to provide conduit which is accessible at the appropriate locations.



Traditional display surfaces

The most traditional display surface is the chalkboard, but the black slate surface of the past has now changed to a porcelainized steel surface available in a variety of colors. For displaying prepared visuals, an easel holding sequential charts, a flannel board, or magnetic board may be used. The flannel board is covered with chemically treated flannel. Anything to be displayed on this surface is backed with a nylon material that will adhere to the flannel even when lightly placed against it. The magnetic board, which may double as a chalkboard, holds charts by magnetic attractors. In addition, classrooms will have some tackboard surfaces which are available in many colors and which can be attached to any surface.

Television monitors and receivers

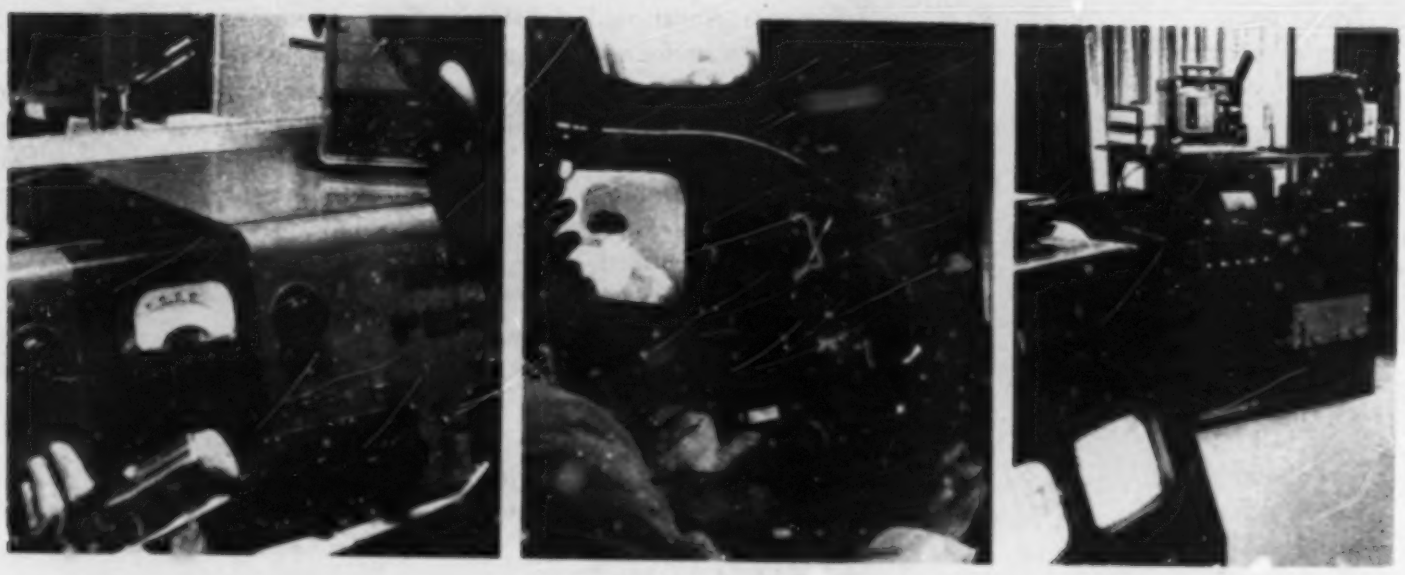
The use of television as a teaching tool has increased greatly since the mid-1950's and with technological improvements and price decreases, it seems destined to be come a standard aid in tomorrow's school. Both monitors and receivers are presently used in schools for reception. A monitor is a high definition set without tuner or audio that is connected directly to a TV camera or to a closed circuit system. A receiver is similar to a home TV set and may be tuned to various closed circuit channels or to off-the-air programs. The introduction of monitors or receivers into the average classroom does not pose special problems for the designer, as long as they are positioned to cover all seats with adequate viewing. However, when they are to be located in a large group instruction room where other media will be used, they require careful placement to avoid interference with other images. When receivers are used, the audio system within the set may be employed for all audio distribution in the room. Monitors will require a separate audio system. There are a number of devices available for hanging the sets from the ceiling or mounting on walls.

Classroom TV systems

The simplest of TV systems is the television camera hooked up directly with monitors, receivers, or a TV projector. This system may be used in a classroom for magnification; a TV camera is located over the lectern slightly above the teacher's head and, by using a zoom lens and auxiliary lighting, graphics, book materials, specimens and small models, may be shown to the entire class. The only requirement for such an internal system is cabling from the camera to the TV receivers and monitors, or to the projector and power outlets. When additional cameras are added, it becomes necessary to add switching devices, which may be portable and located in the classroom, or switching can be controlled remotely.

An "in-house" TV system

If TV originates from an "in-house" studio, distribution will be by coaxial cable to the various classrooms from a control and distribution center. The control center will also contain video tape recorders and film and slide chains. Because of rapid equipment advances, cabling between the studio, studio control and distribution



center should be easily accessible. This may be done by using an elevated floor in these areas or by the use of open cable trays.

Video tape recorders

The importance of Video Tape Recording should not be underestimated, and as the price of the VTR decreases, its use will become more important. Effective educational television today is hampered by the necessity to schedule all classes for simultaneous presentation. VTR's can allow schools to schedule individually to best fit their programs. The use of educational TV stations during off-hours for broadcasting courses to be taped at the schools will make many more hours of special courses available, especially in rural areas.

Television distribution

From a central origination and distribution point, television signals may be carried to viewers or recorders in schools and institutions by several means. Closed circuit systems employing coaxial cable or telephone lines may be extended between buildings. In addition, standard micro-wave and 2500 megacycle transmission may be used from point to point. By employing translators their range may be extended. Of course, conventional, multi-directional broadcast television may also be used. Reception of TV signals at the school requires a receiver antenna carefully oriented for effective reception.

Audio laboratories

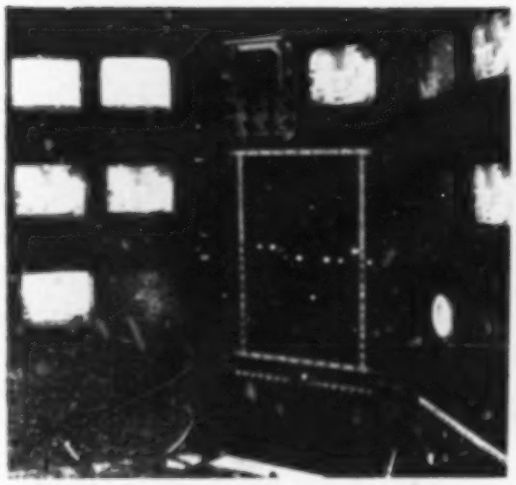
The audio laboratory, formerly known as the language laboratory, is composed of student stations each with audio listening and recording capability, a teacher's console with monitoring capability, and tape storage, recording and playback. There are many different laboratories available, each with its own merits and limitations. As a general rule, the student stations are placed in rows and conduit is run from the teacher's console or tape decks to a floor box at the end of each row. At the console 110-120V 60 cycle, AC current is required.

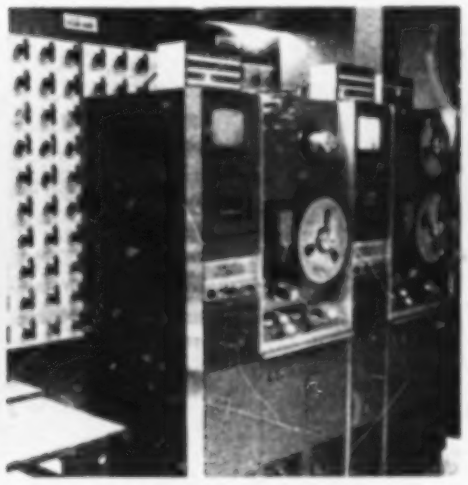
Computers

Previously, the potential of the computer coupled with a student response system for research and analysis purposes was suggested. Some other uses of the computer are as a teaching machine using a branching program, as an information storage and retrieval system, and as an administrative tool for scheduling, record keeping, payroll, and the like. It is impossible to offer general suggestions for planning an efficient computer system since each installation must meet unique local requirements. Computer modules should be placed on a raised floor, the computer room should have a strictly controlled environment, and be relatively dust-free and acoustically treated.

Classroom communication systems

Finally, the architect should be familiar with the combination communications systems that are available for school plants. From a number of origination points, audio and video information may be fed to classrooms, and, in turn, information may be carried between classrooms and from classrooms to offices, studios and so on. Each classroom is equipped with a panel which may contain clock, telephone, intercom, microphone and television jack, light controls, thermostat, emergency call, and the controls for television receivers used within the room. Such a multi-communications system can be built initially, while components may be added as functional usage increases.





The work of the project was greatly aided and assisted by an Advisory Committee who met periodically with the staff, participated in the conferences, and reviewed materials. Those on the committee gave freely of their time and talents.

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